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THE TINGOIDEA OF NEW ENGLAND AND THEIR BIOLOGY[1]

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An Explanation

Throughout the paper previously unpublished species records are cited by naming, in parentheses, the collector or the institution in whose collection the specimens were seen, *e.g.,* (Parshley) or (Cornell University).

All native plant binomials are those used by the late Professor M. L. Fernald (1950) in his recent edition of *Gray's Manual of Botany* and the names of cultivated plants follow Dr. L. H. Bailey's (1949) *Manual of Cultivated Plants.*

The family name Tingidae is used in accordance with Opinion 143 of the International Commission of Zoological Nomenclature.

Introduction

The extensive literature dealing with the Tingoidea of North America includes a wealth of information concerning matters taxo-

nomic but only an occasional careful life history study and scattered notes on tingid biology. The relative unimportance of the lace bugs in an economic sense is responsible for this neglect. However, even a cursory consideration of the Tingidae suggests a variety of problems biologically both interesting and significant.

Before such investigations may be properly initiated, however, a summation of our present knowledge becomes necessary. This paper, therefore, represents an effort to collate, review, and expand our understanding of the Tingidae. Although New England is a restricted portion of the Nearctic faunal area, the species occurring there are sufficiently representative to provide a basis for such work. That the tingid fauna may be considered representative is supported by the following evidence.

The excellent review of the taxonomy of American Tingidae entitled "*Generic Classification of the North American Tingoidea*" (Hurd, 1946) reveals that these heteropterous insects have been most actively studied since 1900, although Fabricius described two American species as early as 1794. By 1886 Uhler could list only eleven genera and twenty-four species from North America. The next thirty years brought an increase to twenty-four genera and seventy-six species from the area north of Mexico (Van Duzee, 1917). Only twenty years later fifty-two genera containing about four hundred and twenty-four species were recorded from the Western Hemisphere (Drake and Poor, 1936). Forty-seven of the genera and over three hundred of the species occur in North America. For eastern North America Blatchley (1926) recorded twenty-two of these genera and seventy-three species. This paper notes forty species and four varieties, falling into fourteen genera, for which there are authentic New England records. One of these species is described as new and one is a recent introduction from the Orient here first recorded from North America. Undoubtedly Blatchley's 1926 totals are no longer valid. However, if we conservatively estimate the present number of known tingid species in eastern North America at approximately one hundred, it is probably safe to assume that a third or more of the total number of species and about half of the genera east of the Mississippi are found in this region. Both in variety of genera and in number of species, therefore, the tingid fauna of New England is truly representative.

General Considerations

Although the main purpose of this investigation is to elucidate tingid biology, as usual in entomological studies, it is first necessary

to determine as accurately as possible the species definitely recorded from the selected geographic area. The over-all problem, therefore, involves a limited taxonomic review. The details of this review will only be included, however, if they are essential to a proper understanding of a particular species. Full bibliographic references will support all taxonomic conclusions and provide ready access to the literature which is available for the New England species of Tingidae.

Two exceptions to the procedure just outlined follow. In the course of this study one new species has been encountered in the field and another species, apparently introduced rather recently from the Orient, has been collected. A full description of the new species is given and the oriental species is redescribed since the original description is in Japanese (Matsumura, 1905) and, although the description is translated in a later edition (Matsumura, 1930), both references are difficult to obtain and the English version is not very satisfactory.

More than a third of the New England species belong in the wholly American genus *Corythucha* Stål. Over sixty species of *Corythucha* (Hurd, 1946) have been described. Fifteen of these occur within the New England area. The species in this genus exhibit considerable intraspecific variation. As a group they appear to be of fairly recent origin and, employing the current taxonomic criteria, specific limits are difficult to determine in some cases. For this reason the external genitalia of males in this genus have been studied to learn whether or not their structural features would aid in the separation of the species. The method of preparation and the results of this approach to tingid taxonomy will be included.

Hurd (1946) has established a generic order that seems sound in the light of our present knowledge. Accordingly, her sequence is followed. For the species an alphabetical arrangement is most satisfactory because of the limited representation of species in any one genus within the New England area. Unless all known species in a genus are compared, a phylogenetic order can scarcely be approximated.

The morphology of the Tingidae presents many clues to evolutionary relationships and many points of interest in general. All are of small size, and they are mostly somewhat dorso-ventrally flattened. The term "lace bug" is quite apt, since membranous structures on the dorsum of many species are of decidedly lace-like appearance. The hemielytra and expanded paranota display a re-

markably delicate areolate condition in some. In others the nervures are more conspicuous and the surface is coarsely or finely punctate. The head is often wholly or partially covered by a more or less inflated pronotal hood. Although the closely related Piesmidae have two ocelli, the Tingidae lack simple eyes. The disc of the pronotum is either uni- or tri-carinate and is prolonged backward as a triangle which covers the scutellum in native species. The hemielytra lack both a distinct clavus and membrane and the cells may be hyaline, or in part whitish opaque, or fuscous. Several genera have marked tumid elevations in the discoidal areas of the hemielytra. Both the antennae and the rostrum are four-jointed. The tarsi have only two joints.

In some species both macropterous and brachypterous forms occur. Intermediate hemielytral lengths may also be common. Sometimes macropterous specimens greatly predominate and brachypterous individuals are rare. In other species the reverse is true. The degree of hemielytral development may even be a secondary sexual characteristic, and sexual dimorphism occurs in the antennae of some species also.

Since we are concerned primarily with the biology of these heteropterous insects, the taxonomic details, although essential, are only of incidental importance. The species included have been thoroughly studied and carefully determined. However, the information necessary for their identification has been reduced to a minimum and is presented chiefly in the form of a key supplemented by figures which portray the diagnostic features of the Tingidae. This plan provides for a full elaboration of all biological information.

Apparently all of the Tingidae are phytophagous. Therefore, a knowledge of their host relationships offers a promising approach to a study of their biology. It soon becomes evident that they show a remarkable diversity in their host preferences. The commoner British species (Butler, 1923) are usually associated with herbaceous plants or with mosses, but the better known American species are generally thamnophilous or arboreal. The degree of host specificity also reveals an interesting range of variation. Since they are usually rather sedentary and in some species, at least, inclined to be gregarious, they may occasionally be collected in large numbers when the host plants are known. Consequently, all information pertaining to the food habits of the Tingidae will be fully considered.

Although little, if any, information concerning their habitat preferences is available, it is obvious that the extremes are determined by the ecological tolerances of satisfactory host plants. However, it soon becomes apparent that certain species are much more restricted in their distribution than are their known hosts. It is only an exceptional species that almost invariably occurs wherever its food plant grows. Examples of both the extremes and of intermediate kinds of distribution patterns will be noted. What the reasons may be for local, disrupted patterns remains undetermined. Full distributional data will be given only for the less well-known species or where the plant-tingid relationship is of particular significance. A source of food is but one factor in the complex of such plant-insect associations.

Probably one of the factors limiting the distribution of some species is the availability of suitable conditions for hibernation in the immediate vicinity. Such conditions may exist only locally within the broad range limits of tolerant host plants. That this may, in fact, be a vital matter is strongly suggested by one plant that itself furnishes favorable winter quarters for its insect parasites. This host is one of the exceptional few that is nearly always infested regardless of local conditions or of its isolation from other plants of the same species.

The problem of overwintering is commonly solved by hibernation of the adults in the duff, under loose bark, or in other suitable shelters. Nymphs have been rarely collected in late winter or early spring and, therefore, some species may hibernate either as adults or as nymphs. One genus, common to North America, Europe, and Asia, overwinters in the egg stage. Species in this genus usually feed on broad-leaved evergreens and the eggs are inserted into the lower surface of leaves that remain on the plants throughout the year. Here again adaptations to the host appear.

Seasonal and climatic influences on plant growth are naturally reflected in the reproductive cycles and activities of the Tingidae. This intimate interrelationship between the plants and the lace bugs deserves special emphasis. The available information concerning life histories and population trends will be broadly studied. In some instances only the seasonal range of the adults can be suggested from the records.

In concluding this general introduction a statement of the methods employed seems pertinent. The information presented was gathered from three main sources. First, a thorough survey

of the literature laid the foundation. Secondly, an appreciable amount of field work and collecting provided specimens and a number of original observations. Finally the laboratory study of this material and of borrowed collections supplied valuable supplementary information. The first method requires no further comment but a brief explanation of the other two seems desirable.

The field work, extending over six seasons, included much general collecting as well as rather specific observations made regularly for two years at selected stations in the vicinity of Boston. During early September of 1949 a two thousand mile drive was taken for the express purpose of collecting tingids in Vermont, New Hampshire, and Maine. Short excursions into south-eastern Quebec and one along the lower St. Johns River in New Brunswick, Canada were also made. Although somewhat late in the season, the trip was satisfactorily productive.

Eight collections of New England Tingidae have been carefully examined in addition to my own. Three of these are especially important while some of the others contained individual specimens of note. These collections have been cited in the acknowledgments above. Records have also been made available to me from other sources. The most notable is a long list of the New England specimens in the United States National Museum very kindly supplied by Dr. Reece I. Sailer. Without the generous cooperation such assistance typifies, this study would be necessarily far less complete.

The Tingoidea of New England

Superfamily Tingoidea Reuter, 1912

There are but two families in this group. The members of both are plant feeders with walking legs. Their antennae consist of four antennites of which the third is the longest. The hind coxae are rotatory and the tarsus is composed of only two tarsites with arolia beneath the claws. The rostrum lies in a sulcus formed by usually prominent bucculae on the underside of the head which are commonly continuous with more or less raised sternal ridges on the thoracic segments. The bucculae and sternal ridges may be membranous with a single row of areolae.

Key to the Families

1. Jugal spines projecting beyond the tylus, their tips free or contiguous. Scutellum exposed. Discoidal area of hemi-

elytron divided by cubital vein. Lunate cavities visible beneath the paranota ..... Piesmidae

Piesma cinerea (Say)[2]

Jugae not surpassing the tylus. Scutellum covered by pronotum in all native species. Discoidal area undivided. No thoracic cavities visible ..... Tingidae

Key to the New England Genera

A. Head spines mostly stout and appressed.

1. Paranota usually poorly developed. Pronotum with three costate carinae and its anterior margin collar-like with no more than a suggestion of a hood.
   a. Hemielytra very convex with only the uniseriate costal area well defined. Small, blackish brown species with third antennite very stout and covered with coarse recurved hairs.
      Alveotingis grossocerata O. and D.
   b. Third antennite longer and slender, the distal end much swollen and fuscous. Large, straw colored species with hemielytral areas distinct. Costal margin uniseriate and flaring erect.
      Melanorhopala clavata Stål
   c. Third antennite much shorter and stouter than in (b), gradually increasing in diameter towards the distal end and clothed with recurved hairs. Costal area uni- or biseriate. Shorter, but otherwise somewhat resembling (b).
      Genus *Hesperotingis*
2. Paranota prominent but closely reflexed against disc of pronotum. Small hood evident at anterior end of median carina never projects forward beyond occiput.
   Genus *Physatocheila*
3. Paranota barely represented by a ridge. Carinae also nearly obsolete. Dorsal surface more nearly punctate than areolate. Very small ..... Genus *Leptoypha*
4. Paranota with three to four rows of areolae, somewhat reflexed and concave above. Pronotal hood transverse and small, not covering head. Antennites of

[2] If only a single species occurs in this region it will be indicated in this key. If more than one is known, refer to appropriate genus in the following keys.

equal thickness, rough and setose. Costal area as wide as discoidal with two slight irregular rows of areolae ..... *Dictyonota tricornis* var. *americana* Parshley

B. Head spines short and stout, bluntly rounded and not appressed. Three small, broadly oval and slightly convex species ..... Genus *Acalypta*

C. Head spines slender, long and freely erect. Paranota foliaceous, their areolae conspicuous.

1. Hood areolate but small, scarcely covering the occiput. Pronotal carinae sub-equal in height. Paranota nearly erect and narrow with one or two rows of areolae. Costal area also uni- or biseriate. General outline elongate rectangular ..... Genus *Leptopharsa*
2. Lateral carinae greatly enlarged and swollen laterally, meeting behind the small areolate hood and well above the median carina. Triangular process of pronotum inflated. Areolae of paranota and hemielytra uniquely large and rectangular. *Galeatus peckhami* (Ashmead)
3. Hood and pronotal carinae as in C 1. Paranota much broader with three to five rows of areolae. Costal area also with three to five rows of areolae opposite apex of discoidal area. Broadly rectangular species with numerous long hairs on the nervures. Genus *Gargaphia*

D. Head completely covered by membranous pronotal hood.

1. Hood elongate, low and flat. Somewhat rounded behind, gradually tapering anteriorly and reaching beyond proximal end of third antennite. Pronotal carinae uniseriate and of sub-equal height. Very small. *Corythaica bellula* Bueno
2. Hood not drawn out anteriorly and not reaching beyond first antennite. Paranota irregularly triseriate and flaring erect. Median carina high, arched, and much larger than the lateral carinae. Genus *Stephanitis*
3. Hood more or less globose behind, usually constricted and tapering in front to reach beyond the proximal end of antennite three. Paranota broadly rounded and essentially explanate with the center bullate. Median carina foliaceous and usually prominent. Genus *Corythucha*

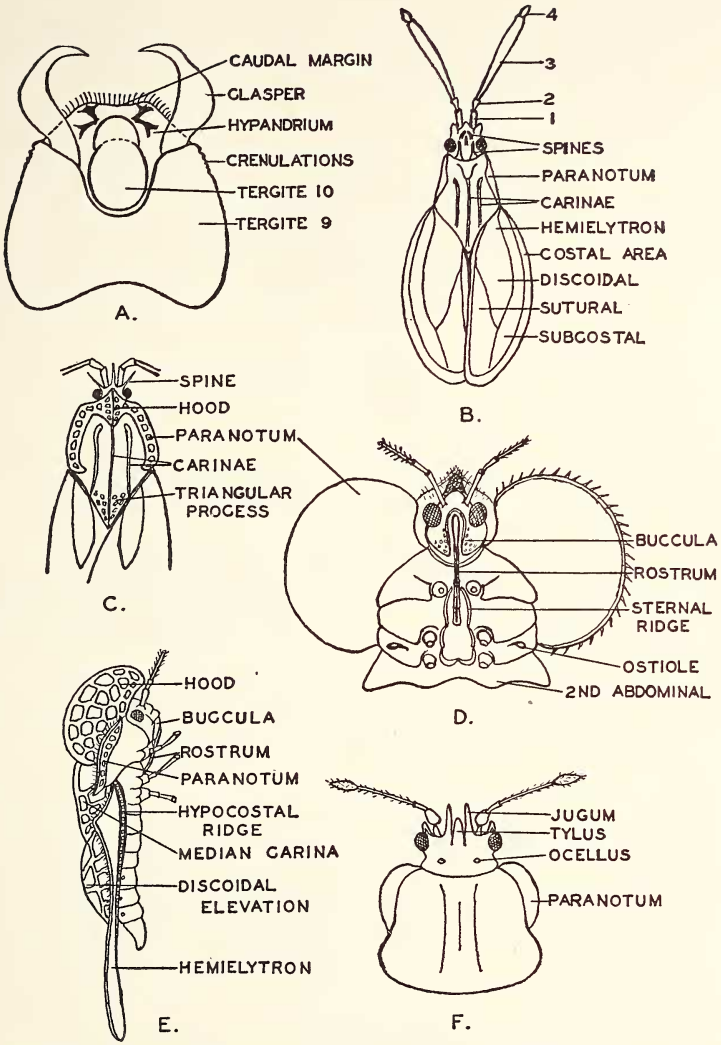


Fig. 1. Taxonomic anatomy of the Tingoidea. A, male genital capsule of *Corythucha,* dorsal aspect. B, *Hesperotingis,* dorsal aspect, after Parshley, 1917a. C, *Leptopharsa,* dorsal aspect, after Parshley, 1923b. D, *Corythucha,* ventral aspect. E, *Corythucha,* lateral aspect, after Parshley, 1923b. F, *Piesma,* dorsal aspect.

Keys to the New England Species of Tingidae[3]

Genus *Hesperotingis*

1. Third antennite fuscous beyond proximal third, fourth antennite sub-conical. Paranota reduced and reflexed. Costal area uniseriate and subcostal area biseriate. *H. antennata* Parshley
   (*H. antennata* var. *borealis* Parshley is distinguished only by its slightly shorter and uniformly dark antennae and by having the subcostal area irregularly triseriate.)
2. Third antennite longer, more arcuate and fuscous only beyond the middle. Fourth antennite fusiform. Costal area rather regularly biseriate and broad. Paranota foliaceous and vertical ..... *H. illinoiensis* Drake

Genus *Physatocheila*

1. Rostrum not quite reaching mesocoxae. Costal area rather regularly triseriate ..... *P. brevirostris* O. and D.
2. Rostrum extending beyond the mesocoxae but not beyond the metacoxae. Costal area rather regularly biseriate. *P. plexa* (Say)
3. Rostrum extending beyond the rostral sulcus to the base of the second abdominal sternite. Costal area varies between a biseriate and triseriate condition ..... *P. variegata* Parshley

Genus *Leptoypha*

1. Costal area biseriate in humeral region and uniseriate posteriorly. Lateral carinae barely discernible. *L. costata* Parshley
2. Costal area with only a few distinct cells at constriction before the apex. This species is much smaller and has shorter antennae than the other two ..... *L. ilicis* Drake
3. Very similar to *L. ilicis* but with distinguishable areolae along the costal margin from the constriction of the hemielytron to the apex. It is also appreciably larger and has longer antennae ..... *L. mutica* (Say)

Genus *Acalypta*

1. Pronotal carinae almost parallel, foliaceous and uniseriate, their anterior ends in line. Median carina but slightly higher

[3] Except for the species keyed out in the preceding key to the genera.

than laterals. Paranota broad, rounded and mostly biseriate. Costal area regularly uniseriate.

A. lillianis Bueno

2. Lateral carinae only areolate in front and slightly divergent behind. Median carina slightly higher in front and more prominent. Paranota narrow, biseriate in front and uniseriate behind, areolae small. Costal area narrow and almost uniseriate ..... *A. nyctalis* Drake
3. Paranota broad and rectilinear. Lateral carinae short, very low, and strongly divergent posteriorly. Median carina raised in front. Costal area with one, two, or three rows of areolae at different points ..... *A. thomsonii* Stål

Genus *Leptopharsa*

1. Costal area rather regularly biseriate. Median head spines relatively short, stout and blunt, lateral pair reduced and appressed ..... *L. clitoriae* (Heidemann)
2. Head spines needle-like, tips fuscous. Hood with three relatively large areolae on each side of the median nervure from front to back. Costal margin irregularly uniseriate except for biseriate section opposite apex of discoidal area, its nervures mostly fuscous ..... *L. heidemanni* (O. and D.)
3. Head spines needle-like and whitish. Hood with four relatively small areolae on each side of the median nervure. Costal margin more regularly uniseriate than in (2) and a shorter portion biseriate. Costal nervures colorless except at apex of hemielytron ..... *L. oblonga* (Say)

Genus *Gargaphia*

1. Lateral head spines reduced, appressed and not visible from above because of hood. Paranota with three rows of areolae at widest point. Paranota and pronotal carinae of sub-equal height. Nervures of pronotal area and of proximal region of hemielytra covered with long, soft hairs.

G. angulata Heidemann

2. Head spines prominent. Paranota conspicuously high and angulate, with five rows of areolae at widest point. Hood laterally compressed and sub-triangular in outline, its crest sub-equal in height with paranota. The pronotal carinae much lower and the three of equal height. First and second antennites fuscous as are some of the dorsal

nervures. Very long hairs on the pronotal and hemielytral nervures ..... *G. solani* Heidemann

3. Head spines prominent and white. Paranota rounded and with four rows of areolae at widest point. First and second antennites pale stramineous. Disc of pronotum invested with whitish pubescence. Hairs on nervures finer, shorter and much less obvious. Nervures all whitish except for two short sections near the widest part of the discoidal area ..... *G. tiliae* (Walsh)

Genus *Stephanitis*

1. Hypocostal ridge uniseriate.
   a. Hood nearly twice as high as crest of the median carina ..... *S. globulifera* (Matsumura)
   b. Hood and median carina of sub-equal height. *S. pyrioides* (Scott)
2. Hypocostal ridge irregularly biseriate..... *S. rhododendri* Horváth

Genus *Corythucha*

1. Hood and median carina of sub-equal height.
   A. All membranous structures whitish except for a small fuscous spot on the discoidal elevation. Male genital capsule large (Fig. 5E) and lacking crenulations before insertion of claspers. Claspers large with untapered, bluntly rounded tips ..... *C. ciliata* (Say)
   B. Basal band and sutural area infuscated. Apical band never developed. Male genital capsule slightly smaller than 1A above and with crenulations before insertion of claspers (Fig. 5D). Claspers tapering and sub-acute at tips ..... *C. caryae* sp. nov.
   C. Usually with both a basal and an apical hemielytral band present, but the pigmentation is variable and the apical band may be entirely lacking. The male genital capsule is small and fragile (Fig. 5A) and the claspers taper to acute points ..... *C. arcuata* (Say)
   D. Both hemielytral bands invariably present. Male genital capsule as in Fig. 6G. The median caudal border of the hypandrium is slightly convex in this species alone and the claspers have unique spatulate tips ..... *C. pruni* O. and D.
2. Hood noticeably higher but less than twice as high as the median carina.

A. Male genital capsule lacking crenulations before insertion of claspers which taper gradually to bluntly rounded tips (Fig. 5H) ..... *C. heidemanni* Drake

B. Male genital capsule with crenulations. Claspers taper to rather sharp tips (Fig. 6A)..... *C. juglandis* (Fitch)

3. Hood at least twice as high as the median carina.

A. Both hood and carina very small and low.

a. Unique in lacking marginal spines on paranota and hemielytra. Male genitalia as shown in Fig. 6D ..... *C. mollicula* O. and D.

b. Hood well rounded behind. Anterior lobe of paranota with large spot and apical hemielytral band prominent. Male genitalia as in Fig. 6F.
C. pergandei Heidemann

c. Hood somewhat flattened on top. Paranota with very small spot and apical hemielytral band lacking. Male genitalia as in Fig. 6H.
C. ulmi (O. and D.)

B. Hood high and somewhat laterally compressed.

a. Most areolae are whitish opaque and many nervures are lightly embrowned. Male genital capsule small and the claspers with extremely long slender, sharp tips (Fig. 6B).
C. marmorata (Uhler)
(*C. marmorata* var. *informis* Parshley differs chiefly in having very short hemielytra that are usually broader than long. Their discoidal area extends behind the middle. Male genitalia are almost identical, as shown in Fig. 6C.)

C. Hood high and globose.

a. Species 3.5 to more than 4.0 mm. long.

a1. Cells of the hood about four times as large as the paranotal areolae. Hood nervures dark. Male genitalia as in Fig. 5B.
C. associata O. and D.

b1. Cells of the hood about twice as large as the the paranotal areolae. Hood nervures pale. Male genitalia as in Fig. 6E.
C. pallipes Parshley

b. Species 2.8 to 3.5 mm. long.

a2. Paranota whitish-opaque and nearly immacu-

late. Cells of the hood about four times as large as the paranotal cells. Genital capsule of the male small and the claspers taper to sharp tips (Fig. 5F). Usually less than 3.0 mm. long ..... *C. coryli* O. and D.

b2. Paranota sub-hyaline and bearing a conspicuous brown spot on the antero-lateral face of the tumid area. Cells of the hood about twice as large as the paranotal cells. Genital capsule of the male larger than in *C. coryli* and claspers with blunter tips (Fig. 5C). This species is usually of intermediate size between a2 and c2 ..... *C. bellula* Gibson

c2. Bullate area of paranota heavily infuscated. Genital capsule of the male larger than that of *C. bellula* and claspers with sharp tips (Fig. 5G). Usually over 3.0 mm. long and darker than other species in this region.
C. cydoniae (Fitch)

Family **Piesmidae** Amyot et Serville, 1843

A single genus represents this family in North America and Europe. In the Nearctic ten extant and one fossil species occur. About a dozen species are known in the Old World (Hurd, 1946). The piesmids show affinities with the Lygaeidae and in the past some students have placed them with the Lygaeidae. Recent hemipterists, however, have more frequently associated them with the Tingidae.

Macropterous piesmids have ocelli and both the clavus and membrane of the hemielytron are distinct. Their external genitalia are much less prominent, especially in the males, than are those of the tingids.

Genus *Piesma* Le Peletier et Serville, 1828

Piesma cinerea (Say).

Tingis cinerea Say, 1832; in Fitch reprint, 1858, p. 793; Say (in LeConte edition), 1859, p. 349.

Piesma cinerea (Say) var. *inornata* McAtee, 1919a, p. 87.

This species and its variety may be treated together since the latter differs only from the usual form in its entire lack of dark markings and since, according to McAtee (1919a), it may occur

anywhere within the range of the species. *Piesma cinerea,* and its variety *inornata,* is the only piesmid known from New England. There are specimens of the variety in the Parshley collection from Rhode Island and from Connecticut. Adults vary in size from 2.75 to 3.25 mm. in length and from 1.3 to 1.4 mm. in width. They may be separated from all other tingoids in this region by the characters given in the family key.

This is one of the commonest and most widely distributed species. *P. cinerea* ranges from Massachusetts to the state of Washington, south to California and Florida. It occurs in Canada, Mexico, and Argentina (McAtee, 1919a; Hurd, 1946). In New England there are records of its occurrence in Massachusetts, Rhode Island, and Connecticut (Parshley, 1917b and 1923b), but it is apparently unknown from the three northern states.

Eggs: The eggs are white to light yellow and are laid on the food plant. Most are placed on the under side of the leaves and close to the larger veins. Unlike tingids, piesmids do not insert the abopercular end of the egg into the leaf tissue. They simply deposit an egg on its side and fasten it lightly with some adhesive substance. In heavy infestations eggs may be laid along the impressed veins of the upper leaf surface, in the leaf axils, or in the dense flower heads of *Amaranthus retroflexus* L. The eggs are laid individually and in no regular pattern. Twenty or more may be found on a single leaf (Weiss and Lott, 1924b). Barber (1924) has given a good description of the egg but my observations make some modifications necessary. The eggs vary in length from about .68 to .72 mm. and in diameter from .25 to .28 mm. The sub-cylindrical chorion tapers to a rounded point at the abopercular end and bears somewhat irregularly spaced longitudinal ridges. The ridges can be seen rather distinctly on the exposed side of the egg, but when the egg is freed from the plant the attached side is seen to be relatively smooth. The opercular end is only slightly constricted. A low ridge borders the operculum which is a little convex and bears a ring of four to seven minute hemispherical protuberances. These chorial processes are evenly spaced and form a ring about midway between the center and the edge of the cap. Barber (1924) states that the operculum is flat and bears only five processes around the edge. Although his observations were made in the Boston area also, local material now before me differs in the features indicated. The convexity of the operculum probably depends on the age of the embryo to some extent, while it may also be affected by preservation. In the eggs at hand the compound eyes are readily discernible as bright pink

spots seen through the transparent chorion. This suggests that the embryo was fairly advanced in development when the eggs were preserved. There is some variation in the number of chorial processes on the opercula of this species. On the few eggs examined (about 10) the number varied from 4 to 7 with 6 occurring most frequently.

There are eggs in my collection taken on June 30 in Boston (Hyde Park) on *Amaranthus retroflexus* L. Weiss and Lott (1924b) found eggs abundant on July 25 on the same host in Moorestown, New Jersey, and observed a few as late as August 30. They also noted adults in copulation on the last date. Therefore, oviposition probably occurs throughout the season from soon after emergence from hibernation until the temperature reaches a critical low (as yet undetermined) in late summer or early fall.

Nymphs: Barber (1924) has described and figured the five nymphal instars. Since his paper is readily available, and since the nymphs are almost invariably found in association with adults, details will be omitted here. It is desirable to emphasize the total lack of dorsal spines on nymphs of this species, however, since the related tingid nymphs are conspicuously spinose.

In their notes for July 25, Weiss and Lott (1924b) point out that all stages of *Piesma cinerea* (Say) were then present but that adults and last instar nymphs greatly outnumbered the others. On August 30 a fair number of adults were seen, but very few fifth instar nymphs.

Adults: According to McAtee (1919a), piesmids are partial to plants of the family Chenopodiaceae. For this reason they are potential pests of such crops as beets and sugar beets. A European species, *P. quadrata* (Fieber), is recorded as the only known vector of the sugar beet leaf curl virus on that continent (Wille, 1929). Early reports in this country indicate that *P. cinerea* (Say) will feed on this host (Bruner, 1891; Osborn and Gossard, 1891). However, it has apparently not yet become seriously destructive. Drake (1928a) records *Chenopodium album* L. as its preferred host. It is said to feed on the young leaves and flower buds of grapes in spring (Walsh and Riley, 1868; Summers, 1891), on the foliage of oak, sycamore, buckeye, and beech, and on *Conocarpus erecta* L. in Florida (Blatchley, 1926). Weiss and Lott (1924b) found them feeding in the flower heads of *Scirpus atrovirens* Muhl. on June 7 and on August 9 in New Jersey. Barber (1924) records them from three species of *Amaranthus*. He states that *A. caudatus* L. was completely destroyed by them. The leaves curled and dropped and buds of partly grown plants were blighted. A form of *A. hybridus*

L. and the weedy *A. retroflexus* L. were also infested. Feeding results not only in a curling under of the leaf margins which shelters the attacking nymphs and adults, but also causes a white mottling of the upper surface. This discoloration of the foliage is so evident that infested plants are readily located. My collections have almost always been from *A. retroflexus* L. which is a common garden weed. Since the Amaranthaceae are closely related to the Chenopodiaceae, these host selections are not surprising. However, Barber andWeiss (1922) report them as locally common on horse-chestnut in New Jersey. Professor Parshley (1917b) found one in ocean drift. One specimen in my collection came from a Japanese beetle trap.

Hibernation is undertaken by adults and they have been found under bark of oak and sycamore and about logs (Blatchley, 1926). To these situations Drake (1928a) adds bark of birch and in fallen leaves. A specimen in the Parshley collection was found hibernating in a spider egg case. They probably crawl into any suitable and convenient shelter when cool weather comes.

In a long series taken on *Amaranthus* in West Newbury on July 22, 1950, a single specimen was found with a larval mite attached just under the base of the right hind wing. This is the only direct evidence of parasites, though they may be more frequent than this would indicate. The mites are of such small size that in such a position they would be easily overlooked, and it is only by chance that an occasional one would be noticed.

Adults are active locally from June 16 to August 24 at least, since my collections include those dates. Actually, their season of activity probably extends from a few weeks earlier in the spring until somewhat later in the summer. As for so many common species, more accurate information is not available. Records for eggs and nymphs suggest more or less continuous reproduction throughout the summer with perhaps two main broods. Development from egg to adult may require about six or seven weeks. Verification of the number of annual broods and of the cycle from egg to adult is yet to be done, however.

Family Tingidae Laporte, 1832

Members of this family may be as small or somewhat larger than piesmids. Species with the lacy, expanded paranota and hemielytra are rather rectangular in outline, while those in which these structures are more minutely areolate are usually more nearly oval in shape. In all New England tingids the pronotum has a posterior triangular process that covers the scutellum. They never

have ocelli. The hemielytra lack a clavus and the membrane is undifferentiated. The tylus always exceeds the jugae which are inconspicuous. Their more general characteristics have been previously discussed. Thirteen genera occur in the New England area.

Genus *Alveotingis* Osborn and Drake, 1916

Alveotingis grossocerata Osborn and Drake, 1916a, p. 245, Fig. 9.

This genus and species is based on a specimen taken on August 5, 1913, by Professor Osborn in Orono, Maine. A figure of this brachypterous form accompanies the original description. Parshley (1917a) notes that the type is a male and points out that the plate is inaccurate in some respects. The antenniferous tubercles are not as shown but developed as in the related genus *Melanorhopala* Stål. The third antennite is evenly clavate and not fusiform as drawn. Osborn and Drake (1917a) give a photograph of the type and note the same antennal errors in their original figure. Although Professor Parshley also considered the hemielytral areas more distinguishable than the drawing suggests, they are certainly not readily discerned in the brachypterous individuals before me. Undoubtedly there is some variation in this feature. These specimens agree with his other criticisms, however. The rostrum reaches the mesocoxae. *A. grossocerata* is rarely collected and nothing is known of the early stages nor of the habits of this small tingid. Macropterous adults are 3.4 mm. long and 1.4 mm. wide, while the brachypterous forms are 2.0 mm. long and 1.2 mm. wide.

The species has been found in these additional localities: Great Barrington, Massachusetts (Bueno, 1931); Franconia (Parshley, 1920c), Mt. Washington, and Durham, New Hampshire; New Haven (two records), North Branford, Westport, and Easton, Connecticut. Of the four specimens in the New Haven Experiment Station collection, two are females. One of these is macropterous. This is also true of the Great Barrington specimen reported by Bueno (1931) and of a female from Mt. Washington described by Parshley (1917a). The seasonal range is suggested by two Connecticut records for the year 1920. The earliest was June 12 and the latest August 16.

Only three bits of ecological information are available. Bueno (1931) noted that the Great Barrington specimen was found on a rock on the shore of Lake Buel and he took one elsewhere on a thistle (Drake, 1928a). One of the New Haven specimens bears a pin label stating that it was swept from grass.

In addition to the New England records, the species was found in White Plains and on Long Island in New York (Drake, 1928a) and is also known from the Delaware Water Gap in Pennsylvania (Blatchley, 1926). The genus is restricted to North America.

Genus *Melanorhopala* Stål, 1873

Melanorhopala clavata Stål, 1873, p. 130.
Tingis (*Melanorhopala*) *lurida* Stål, 1873, p. 131.
Tingis (*Melanorhopala*) *uniformis* Stål, 1873, p. 131.
Cantacader henshawi Ashmead, 1886, p. 20.
Melanorhopala obscura Parshley, 1916b, p. 167.
Melanorhopala reflexa Blatchley, 1926, p. 492.

In several papers Professor Parshley (1917a, 1919a, 1920c) and Professor Drake (1926, 1930) cleared the confused taxonomy of this species. This confusion arose when Stål described *M. clavata*, *M. lurida*, and *M. uniformis* without noting that certain antennal characteristics were always associated with males and others with females and without making allowances for structural variations associated with the brachypterous or with the macropterous condition. Drake (1926) finally obtained drawings of Stål's types, which confirmed the view that *M. lurida* Stål is the male of *M. clavata* Stål and that *M. uniformis* Stål is a brachypterous female of the same species. Parshley (1919c) had previously decided that his *M. obscura* was probably the male of *M. clavata* Stål and also synonymous with *M. lurida* Stål. In 1926 Blatchley described *M. reflexa* from Florida. Drake (1930), having examined Blatchley's type, relegated *M. reflexa* Blatchley to the synonymy of *M. clavata* Stål also. In his opinion it was simply an extremely long-winged individual with no other indications of specific distinctness. Sexual dimorphism, combined with the common tendency for variation in degree of wing development among the Heteroptera, was largely responsible for the synonymy of this species.

M. clavata Stål is widely distributed in North America. It ranges from Manitoba, Wyoming and Colorado to Maine, Long Island (Hurd 1946) and Florida (Drake, 1930). New England records include Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut. Although several collections contain numerous specimens, little is recorded concerning their habits. A long series collected on weeds near Chicago (Drake, 1930) is mentioned. Blatchley (1926) took specimens while sweeping herbage in dense woodlands and low meadows, and by beating foliage

of black oak. He also notes that Bueno got them while sweeping rank weedy places near swampy meadows. The few I have taken in Maine and Massachusetts were swept from herbs where *Solidago* was a common element in the cover. Professor Parshley told me that he took many on *Solidago* on Long Island. One of the two other species now recognized in this genus (*M. infuscata* Parshley) was recorded from *Liriodendron* in Maryland and Virginia. An individual of this species was actually found at sap of this tree (Parshley, 1920c).

Eggs and nymphs of *Melanorhopala* have not been described.

Adults range in size from 4.25 to 6.8 mm. long and are 1.4 to 2.0 mm. wide. Therefore it is one of our larger tingids. The earliest New England record at hand is June thirteenth for Branford, Connecticut (Parshley, 1923b) and the latest is August twenty-seventh for a specimen from Swans Island, Maine and for one from Durham, New Hampshire. Adults are probably active from early June until September or even later.

Genus *Hesperotingis* Parshley, 1917a

Hesperotingis antennata Parshley, 1917a, p. 21, figure 2.
Hesperotingis antennata var. *borealis* Parshley, 1917a, p. 23.

Little information is available concerning the habits of *Hesperotingis antennata* Parshley. This medium-sized tingid has been so rarely taken that less than a score of records were located antedating Bueno's paper of 1946. Nothing is known concerning the immature stages nor of the actual food habits of this species. The variety *borealis* is known only from the holotype and possibly two other specimens (Froeschner, 1944; Hurd, 1946). The former was taken in Hampton, New Hampshire, and one of the others came from the District of Columbia, while the third was taken in central Missouri. This variant, therefore, probably occurs throughout the known range of the species since the records of typical forms include Franconia, New Hampshire (Cornell University collection), Dunedin, Florida (Blatchley, 1928b), and Columbia, Missouri (Froeschner, 1944). Adult females vary in length from 3.7 to 4.5 mm. and are 1.5 mm. wide. Variation in length is primarily a matter of hemielytral development. Individuals with long, short, or with intermediate wing lengths are mentioned. In three summers, Bueno (1946) collected the notable total of 50[4] specimens in

[4] The figures given by the author are not consistent with his recorded specimens.

the same locality at Tannersville, New York. Eleven, or about 20%, were macropterous.

New England records include Franconia, Hampton (August 15), and Durham (July 16), New Hampshire; Northboro (June 24), Massachusetts; New Haven (September 4; Olsen, 1923) and Granby (July 4), Connecticut. The earliest seasonal record seems to be June 24, 1937 (Northboro, Massachusetts; C. A. Frost) and the latest September 6, 1932 (Tannersville, New York; Bueno, 1946).

Concerning the habitat preferences of *H. antennata* Parshley, Bueno (1946) states: "They were taken by sweeping low—in fact by scraping the ground itself—on both sides of a footpath running through bushes and on the mowed area, in the longish grasses, close to their roots. They also seemed to be found in the shade, preferably of willow; the foodplant was indeterminate, under the conditions. There was the usual weedy growth—grasses, sedges, trailing blackberry, goldenrods, plantain, meadow sweet, overgrown here and there by stunted willows, young aspens and blackberry bushes, except, of course, in the grassy part of the meadow—a wide choice of food plant, in the absence of direct observation."

Again: "The greater part of the specimens was taken either on a footpath about 50 feet long, through bushes; or else along the edges of a tree-grown space not over 100 feet long. The species was sought in other parts of the field, but without success, except in one instance. It was never found in or among tall grasses."

And: "The only fairly certain thing about the habitat is that they are found more or less in the shade of trees and bushes, since they seem preferably swept along the edges of footpaths or of mowed areas where the grasses are again tall."

The University of New Hampshire collection includes the Durham specimen which bears the label "on *Andropogon.*" Froeschner (1944) records one of the Missouri specimens as "swept from an overgrown field that had formerly been under cultivation."

A final bit of ecological detail is reported by Blatchley (1928b). On three occasions in January he obtained several brachypterous individuals by beating bunches of Spanish moss hanging from the lower limbs of *Quercus rubra* L. in open pine woods in Florida. None were taken from the same epiphyte on pines nor on other trees in the same area. This indicates hibernation of adults, and the exclusive association with the oak may or may not be significant.

Hesperotingis illinoiensis Drake, 1918, p. 88.

Four tingids collected in South Meriden, Connecticut on July 3, 1939, by Mr. Harry L. Johnson, and now in the New Haven Agricultural Experiment Station collection, could not be certainly identified with any known species on the basis of published descriptions alone. Since types and paratypes were not available, it was necessary to send the four specimens to Professor Drake who kindly determined them as *H. illinoiensis*. He originally described this species from three individuals taken in Palos Park, Illinois, by Mr. W. J. Gerhard. The type is not in the Cornell University collection as erroneously reported (Drake, 1918).

These two collections represent the only records for this species as far as I can discover. The Connecticut material includes a female and three males. In length they vary from 3.8 to 4.2 mm. and in width from 1.3 to 2 mm. Two rather regular rows of costal areolae readily distinguish *H. illinoiensis* Drake from the other known hesperotingids. Nothing is recorded concerning the biology of this species. Like the genus *Melanorhopala*, *Hesperotingis* is strictly North American in distribution.

Genus *Physatocheila* Fieber, 1844

Physatocheila brevirostris Osborn and Drake, 1916a, p. 243.

This is another species known only from scattered records of adults. There is nothing available concerning its habits nor about its biology. In size and coloration *P. brevirostris* O. and D. closely approaches *P. plexa* (Say). The two are separable on the basis of the short rostrum and triseriate costal area of the former. Two males before me, collected by Mr. C. A. Frost in Natick, Massachusetts, have remarkably short beaks that just fail to reach the mesocoxae and their costal areolation is fairly regular. One specimen in the New Haven Experiment Station collection, taken on May 9 in New Haven by Mr. H. P. Zappe, appears to be identical. However, four others in the same collection, identified as *P. brevirostris* O. and D. by Professor Parshley some years ago, have much longer rostra and the costal margins are more nearly biseriate, though partly and irregularly triseriate in two individuals. These four seem more properly *P. plexa* (Say). Variation in hemielytral areolation is very likely to occur in tingids. Therefore it is unfortunate that larger series are not at hand for comparative analysis. In other tingids there is also enough variation in the length of the rostrum to make reliance on that feature alone unsatisfactory.

Under present circumstances this interpretation must stand for want of more adequate materials. Although, for the above reasons, records in the literature are certainly questionable, *P. brevirostris* O. and D. has been reported from Massachusetts and Connecticut only for New England. Elsewhere it apparently ranges from New York and New Jersey west to Ohio and south to Virginia (Blatchley, 1926). The recorded seasonal activity covers the period from early May into early July. This, however, is undoubtedly subject to extension when more information becomes available. In color the adults are a uniform soft reddish brown. They are about 3.2 mm. long and about 1.6 mm. wide.

Physatocheila plexa (Say), 1832.

Tingis plexus Say, 1832; in Fitch reprint, 1858, p. 794; Say (in LeConte edition), 1859, p. 349.
Physatocheila parshleyi Osborn and Drake, 1917b, p. 156.
(*non Physatocheila plexa* Osborn and Drake, 1916a, p. 242, 1917b, p. 156.)

There must always be a degree of uncertainty in the recognition of Say's species. However, in this instance the interpretation of Professor Parshley (1916b) seems the more plausible. Van Duzee (1917b), Barber and Weiss (1922), and Hurd (1946) also concur with Parshley rather than with Osborn and Drake (1917b). *P. plexa* (Say) is distinguished from *P. brevirostris* O. and D. by having the rostrum extend beyond the mesocoxae and by having the costal area usually rather regularly biseriate. Parshley (1916b) describes the color as a uniform dull yellowish brown and states the length as 3.0 to 3.2 mm. and the width as 1.1 mm.

There are many more records for this species than for *P. brevirostris* O. and D. Its known range extends from Quebec south to Virginia and from Maine to Oregon (Hurd, 1946). There are New England records for Maine, Massachusetts, Rhode Island, and Connecticut.

Mr. C. A. Frost collected specimens as early as May 2 and as late as November 12 by sifting duff in Ashland and Sherborn, Massachusetts. This indicates hibernation of the adults. Blatchley (1926) also notes that Bueno took specimens on oak and McAtee found them on hickory and on laurel. Proctor (1946) reported the species from Great Heath on Mt. Desert Island, Maine. Barber and Weiss (1922) record material from willow in New Jersey. These few ecological items are no more than hints concerning the possible

host plants of *P. plexa* (Say). This species is apparently active from early May (May 2, Kingston, Rhode Island, Parshley, 1917c) until late September (September 27, Mt. Desert, Maine, Proctor, 1946). Localities cited for *P. plexa* (Say) in New England include Westbrook, Maine (Parshley, 1914); Pinkham Notch, New Hampshire (Museum of Comparative Zoology); Wilmington, Massachusetts (*fide* Sailer); Providence, Rhode Island (Parshley, 1917c); and Brookfield (Parshley, 1923b) and Lyme (*fide* Sailer), Connecticut, in addition to those mentioned above.

Physatocheila variegata Parshley, 1916b, p. 166.

Physatocheila plexa Osborn and Drake, 1916a, p. 242.

P. variegata Parshley is the most frequently collected of our three New England species. It is also most easily distinguished. In color it is predominantly greyish brown, but there is a mottling effect of darker and lighter areas. The areoles of the costal area show considerable variation between a biseriate and a triseriate condition. The arrangement is usually intermediate between these extremes and noticeably irregular. The length of the rostrum is also diagnostic. It always exceeds the length of the rostral sulcus and usually projects beyond the base of the second abdominal sternite, often reaching the middle of that segment. *P. variegata* reaches a length of 3.4 to 4.0 mm. and a width of 1.3 to 1.5 mm.

Again there is no definite information concerning its food habits. A few field notes suggest an association with trees when they flower in spring. Barber and Weiss (1922) report the species from hickory and willow (May 21). White pine is noted by Blatchley (1926). Froeschner (1944) took two females from small branches of a willow near a stream in Missouri (May 11). Proctor (1946) mentions specimens from catkins on Mt. Desert Island, Maine, April 27). There are specimens in the United States National Museum (*fide* Sailer) taken on willow catkins in Bar Harbor, Maine (April 28 and May 11). Proctor (1946) also recorded specimens from the Great Heath on Mount Desert Island (September 25). Mr. C. A. Frost has collected this species in Framingham, Massachusetts by sifting on November 17 and 25 and on December 25 (*fide* Sailer). This is all that is known concerning the hibernation of adults. He has also collected them by sweeping in Sherborn (May 30 and June 20) (*fide* Sailer) and in Framingham (June 1), Massachusetts. The extent of seasonal activity is shown by the Mt. Desert Island records for April 27 and September 25 given

above. New England localities include Orono, Maine (University of Massachusetts); Zealand Camp in the White Mountains (University of Massachusetts) and Durham (University of New Hampshire), New Hampshire; Blue Hills, Holliston (Museum of Comparative Zoology), Natick (Blatchley, 1926), Ware (H. G. Barber) and Wellesley (Parshley), Massachusetts; and Brookfield and Portland, Connecticut (Parshley, 1917c), in addition to those previously listed. Outside of New England the species ranges from New York (Osborn and Drake, 1917b) to British Columbia (Parshley, 1919c) and south to Missouri (Froeschner, 1944) and Virginia (Osborn and Drake, 1917b). The last reference lists most of the states from which the species has been recorded. In this genus about thirty species are recognized. Only four are North American. The rest are chiefly Palearctic in distribution.

Genus *Leptoypha* Stål, 1873

Leptoypha costata Parshley, 1917a, p. 16.
Leptoypha distinguenda Heidemann, 1917, p. 218, Pl. 17, Fig. 1.

The genus *Leptoypha* is primarily North American, and three species of these small tingids are recorded from New England. *L. costata* Parshley is easily distinguished from the other two by its costal area which is biseriate in the humeral region and then uniseriate to the apex of the hemielytron. *L. mutica* (Say) has the costal area so reduced that areolae are distinguishable only behind the middle of the hemielytron and even fewer areolae may be seen in *L. ilicis* Drake. The lateral carinae are barely discernible in *L. costata,* but quite obsolete in the other two species. A specimen of *L. costata* before me is noticeably broader and much paler than any local material of *L. mutica* at hand. This male measures 2.7 mm. long and 1.15 mm. wide. Parshley (1917a) gives the length of the female as 2.8 mm. and the width as 1.3 mm.

The only New England record located for *L. costata* Parshley is on the list kindly furnished by Dr. Sailer. The locality is Stamford, Connecticut (July 20, 1939), and carries the notation "reared from red ash." A Louisiana specimen on the same list was taken on *Hicoria alba* (now *Carya tomentosa* Nutt.). McAtee (1923) reported a collection from *Fraxinus caroliniana* Mill. and suggests that an earlier indication that witch-hazel is a food plant for this species is probably an error since repeated sweeping of witch-hazel by him failed to yield any specimens. Drake (1925) took large numbers of *L. costata* Parshley on *Fraxinus* in Mississippi, which

further supports McAtee's view. Outside of New England the species is known from Maryland, the District of Columbia, Virginia, Colorado, Arkansas, and Illinois (Drake, 1918).

Leptoypha ilicis Drake, 1919a, p. 420.

Drake (1919a) emphasizes the close affinity of this species and *L. mutica* (Say). It differs from the latter in being much smaller and in having shorter antennae. *L. ilicis* is said to be dark reddish brown and, like *L. mutica,* lacks the lateral carinae and has even fewer costal areolae. These features separate this species from *L. costata* Parshley. The length is given as 2.21 mm. and the width as .87 mm.

The few records (Drake, 1919a, Blatchley, 1926 and 1928b) report this species from Stone Mountain, Georgia, and from Florida. However, Hurd (1946) adds Texas, Oklahoma, and New Hampshire to the list. The distribution of *L. ilicis* is so predominantly southern that the New Hampshire record certainly needs verification.

As the specific name implies, this species was collected on *Ilex* in Georgia (Drake, 1919a). Blatchley (1928b) found one while beating *Vaccinium* and Hurd (1946) records palm jungle sweepings as a source of specimens.

Leptoypha mutica (Say), 1832.

Tingis mutica Say, 1832; in Fitch reprint, 1858, p. 794; Say (in LeConte edition), 1859, p. 349.

Leptoypha mutica (Say) is better known than the two species just considered. However, it is by no means common and only occasionally locally abundant in my experience. In color it is usually dark reddish brown but may be lighter or, according to McAtee (1917a), almost black. Drake (1919a) stressed a close resemblance to *L. ilicis* Drake, which is distinguished chiefly by its smaller size. *L. mutica* is 2.9 to 3.0 mm. long and 1.0 to 1.1 mm. wide (Osborn and Drake, 1916a).

The species ranges from Quebec to North Dakota and south to Florida and Texas (Blatchley, 1926). Records for New England include the first for Maine (by Little Wilson Stream near Willimantic, September 5, 1949) and two previously unreported for New Hampshire (Durham, September 15 and 30 and Lakeside, September 9, 1949). Parshley (1922b) noted the species from Lexington, Massachusetts (June 25) and my collection includes specimens from

Sherborn (June 8 and August 24), and Dover (June 16), Massachusetts. These scattered records for the northeast indicate that the species is more prevalent than can be demonstrated at present.

Egg: Dickerson and Weiss (1916) describe the eggs as follows:

> "Length 0.36 mm.; greatest width 0.22 mm. The somewhat flask-shaped, smooth, whitish eggs were found on the under surface of the leaf, inserted as a rule in the mid-rib, but sometimes in the leaf tissue adjoining the mid-rib. Usually they occurred in small clusters, being stuck sometimes vertically in the tissue and at other times at an angle. The necks of the eggs seemed to be bent slightly so as to bring the cap on a level with the leaf surface. Where many eggs were found in a mid-rib, a distortion was present, the rib extending out on one side and being thickened at that point. The tissue surrounding the eggs was somewhat hard and corky and each egg-cap was topped by a brownish scab-like crust evidently deposited by the parent insect."

In this case the host plant was *Chionanthus virginicus* L. growing in a nursery in Hammonton, New Jersey.

Nymphs: In the same paper the authors (Dickerson and Weiss, 1916) describe each of the five nymphal instars. A fine plate figuring the egg, nymphal stages, and the adult accompanies the article. The paper is summarized and the plate reproduced in a pamphlet entitled "*The Lace Bugs of New Jersey*" (Barber and Weiss, 1922). Both publications are generally available.

Dickerson and Weiss (1916) observed many nymphs on the upper side of the leaves where the foliage was dense and shaded. They found that after the second instar the nymphs dispersed somewhat and fed singly or in groups on any shaded portion of a leaf. The plants in the nursery were infested from top to bottom. All nymphal stages were present on July 7 and very abundant on August 15. By September 1 only fifth instar nymphs were found.

Adults: Plants in the family Oleaceae are the hosts for this species. My four New England collections of *Leptoypha mutica* (Say) were all from *Fraxinus*. In only one place (Sherborn) were they at all numerous. There they were mostly feeding on the upper surface of leaves of suppressed ash seedlings growing under a canopy of mature hardwoods on a dry, gravelly knoll. The majority were resting parallel with the slightly depressed mid-rib and were very inconspicuous in that position. When the leaves were touched the tingids would commonly let go and drop off, thus avoiding

capture. Although the species is often reported from *Chionanthus* where that plant occurs, Dr. Sailer states that specimens from this host show constant differences in repeated collections from Plummers Island (near Washington, D. C.), and in material from Clifton, Virginia he observed the same tendencies. Hereabouts *Chionanthus* is occasionally grown as an ornamental, but there has been no opportunity for me to make an intensive search for *Leptoypha* on this host. Drake (1918) reported specimens collected on *Adelia acuminata* (now *Forestiera acuminata* (Michx.) Poir.) in Texas and stated that Heidemann got a long series at a light in Maryland. Adults have been found hibernating among old leaves (McAtee, 1917a).

Characteristic lace bug feeding damage is described by Dickerson and Weiss (1916). Practically all leaves of the white fringe bushes in the Hammonton nursery were injured. At first there was a whitish discoloration of the upper surface near the mid-rib. Such light patches enlarge with continued feeding until the entire leaf becomes mottled and in severe infestations the leaves actually turn yellowish brown and eventually wither. On the under side the leaves are spotted with the brownish excrement of the nymphs and adults. If the leaves are exposed to direct sunlight most of the insects remain on the lower surface. Where the leaves are shaded they will be found on the upper side.

The New England records reveal a period of activity extending from June 8 to September 30. McAtee (1919b) reports captures from April 11 to October 12 on Plummers Island. Although the various stages have been adequately described, there is as yet no definite information concerning the time necessary for development.

Genus *Dictyonota* Curtis, 1827

Dictyonota tricornis Schrank var. *americana* Parshley, 1916b, p. 164.

There are about twenty-four species in the genus *Dictyonota* and the majority of them are Palearctic in distribution. The only American representative is this variety of a European species known to occur in the northeast from Nova Scotia to Mt. Desert Island, Maine. Parshley (1916b) and Hurd (1946) both mention the possibility of its introduction from Europe. However, Parshley (1916b) was able to compare it with European material of *D. tricornis* Schrank and considered it distinct in a varietal sense.

This insect is a dull greyish brown to black. The general form

is oval. Antennae are thick, rugose and spinous. The pronotum is tricarinate and the small hood does not project over the head. There are no discal elevations on the hemielytra and the costal area is as wide as the discoidal and has two slightly irregular rows of areoles. The bucculae are open anteriorly and the sternal ridges are but slightly elevated. The rostrum reaches a little beyond the metasternum. Males have strongly developed claspers. The variety is 3 mm. long and 1.2 mm. wide.

Since the North American records for this insect are so few they are given in detail. The holotype is a male from Eastport, Maine (July 15, 1909) in the Parshley collection. There are two paratypes, one from Machias, Maine (July 26, 1906), and the other from Roque Bluffs, Maine (July 15, 1907). Both are in the Museum of Comparative Zoology collection. Parshley (1923a) gives two later records for Nova Scotian localities. One is Kings County (July 4, 1921) and the other is Truro (July 21, 1920). The final record seems to be the one given by Proctor (1946) for Mt. Desert Island, Maine (August 29). It is interesting to note that five of the six specimens known were taken in July. On September 8, 1949, a full forenoon was spent sweeping a wide variety of herbs, shrubs, and other vegetation in Roque Bluffs for this tingid but without success.

Since there is no other information about *D. tricornis* var. *americana* available, it is worthwhile to quote Butler (1923) concerning the habits of the species in Europe. The eggs are said to be unknown, but he describes the last instar nymph and states that adults occur from June to October. Then:

> "Unlike most Tingidina, this species is usually found singly, and occurs, as a rule, by promiscuous sweeping, but I have not found it anywhere common. Curtis found the specimen upon which he erected the genus under a stone in a meadow near Bognor, Sussex; and Bedwell tells me he frequently finds it in the crevices between blocks of chalk, flint, etc., on the Downs in the Box Hill district. As food-plants Horváth gives Mentha, Artemisia, and Thymus, and Carr adds broom (*Cytisus scoparius*). Dubois took it in summer by beating pine trees. Douglas and Scott give 'among grass and moss in dry sandy places.' Morley gives sandpits, nests of *Myrmica rubra,* and at roots of *Sedum acre.* Donisthorpe has found both imago and larva in nests of *A. flavus,* and J. Salberg gives *A. niger.*"

Genus *Acalypta* Westwood, 1840

Orthosteira Fieber, 1844; *Orthostira* Fieber, 1861; *Fenestrella* Osborn and Drake, 1916a; *Drakella* Bergroth, 1922.

Approximately 35 species have been described in the genus *Acalypta*. Butler (1923) states that 24 Palearctic species are known, and Hurd (1946) notes ten American and one Japanese species. Very little, however, is recorded concerning the biology of any of them. The European representatives have usually been collected in association with mosses on stumps, on the dry borders of woods and hills covered with low grasses and heath, about the roots of certain herbs in sandy places, sometimes apparently living with ants (like *Dictyonota*), and even under dry ocean drift (Butler, 1923). They have been more often found by patient search of such habitats than by sweeping.

The description of one American species is based on a female found in drift on the shore of a reservoir in British Columbia (Downes, 1927). In my collection there are a dozen specimens given to me by K. A. Christiansen. They were obtained from oak leaf duff from Corvallis, Oregon, which he was putting through Berlese funnels for Collembola. Sources of our New England species will be enumerated below.

Although the eggs of all species remain undescribed, Butler (1923) describes the nymphs of three of the six British species and figures one of them in an outline drawing which completely fails to suggest the actual appearance of the immature insect since the numerous simple and stellate dorsal spines are entirely omitted. The few specimens at hand suggest that these processes would furnish useful criteria for distinguishing the different nymphal instars if only enough material were available for examination and for study of the limits of variation in the form and position of these structures. They might also aid in specific identification of the nymphs.

Acalypta lillianis Bueno, 1916, p. 39.

Acalypta ovata Osborn and Drake, 1916b, p. 9, Fig. 1.
Acalypta grisea Heidemann, 1917, p. 218, Pl. 17, Fig. 2.
Acalypta modesta Parshley, 1921, p. 4.

Acalypta lillianis Bueno is the best known of the three New England species. Members of this genus are small, rather oval, and the hemielytra are only slightly convex. The paranota and

costal margins are explanate and the relatively large areolae of these areas form a rather continuous border. The pronotum is tricarinate and the hood but slightly produced between the conspicuously large and coarsely faceted compound eyes. Areolae are generally rounded and the nervures strongly raised. The color is greyish black. Both brachypterous and macropterous forms are known. Brachypterous individuals are 2.3 mm. long and 1.2 mm. wide, while macropterous specimens are 3.0 mm. long and 1.6 mm. wide. Since this species is widely distributed some variation in size and color is to be expected. Figures of both brachypterous and macropterous individuals are given by Osborn and Drake (1917a), (see Parshley, 1917a for criticism), and Heidemann (1917) figures the brachypterous form.

In New England, specimens have been taken at The Forks (Parshley, 1917c), and Orono (Parshley), Maine; Durham (Osborn and Drake, 1916b—as *A. ovata* O. and D.), and Franconia (*fide* Sailer), New Hampshire; Amherst (University of Massachuchusetts), Andover (*fide* Sailer), Attleboro (Parshley), Canton and Dover (Bailey), and Provincetown (*fide* Sailer), Massachusetts. *Acalypta lillianis* is widespread and has been reported from Quebec to British Columbia and south to Iowa and Maryland (Hurd, 1946).

Nymphs: Bueno (1916) reported nearly mature nymphs found under stones on November 25, December 5, March 5 and 19, and April 2. This makes it evident that nymphs hibernate. Three nymphs in my collection were taken on July 7 and each represents a different instar. Another taken on August 2 in the same locality (Canton, Massachusetts) seems to be the final stage. These immature specimens were taken by sweeping the haircap moss, *Polytrichum,* where adults had been collected earlier in the season. Drake (1928b) found nymphs and adults in low wet mossy areas on the virgin prairie near Ames, Iowa.

Adults: The Andover specimen (*fide* Sailer) was found under a stone in April, which suggests that adults also hibernate. The period of adult activity is only between June 2 and June 27 according to the New England records seen. However, Drake (1928a) reports them from May into August for New York, and Bueno (1916) took most of his type series in late May. The little evidence at hand points to a short period of adult availability during late spring. My first success collecting them came on June 10, 1948, when 18 were taken in less than an hour of sweeping *Polytrichum.*

On June 17 a few more were collected in the same Canton locality. Since then, however, I have never found more than one or two at a time. During the spring, summer, and autumn of 1949 and 1950, numerous attempts in the same patches of moss were fruitless. There is something about the habits of this species yet to be explained. Since European species of *Acalypta* have been found associated with plant roots and in ant nests (Butler, 1923), it may be that *A. lillianis* spends most of its time beneath the surface of the soil and possibly only for a few days early in the season are adults at all common above ground, when they may emerge for mating or some other special purpose. Or, more simply, the species may be nocturnal in habit and retire under stones by day. There is, nevertheless, something unusual about the habits of species of *Acalypta* which may account for the scattered records and the varied conditions under which they have been found.

Other habitat situations noted for this species include damp marshy meadows where the tall tree-like moss (*Climacium americanum* L.—according to Blatchley, 1926) grows in clumps (Bueno, 1916), under mosses on rocks in May (Parshley, 1921); and H. G. Barber collected a long series under a board (Drake, 1928b). Drake (1928b) also stated that Henderson took hibernating adults in Iowa in early April. In the type locality Bueno (1916) collected them in small numbers from mid-May until the end of the month and records a specimen taken in Michigan on July 14.

An abortive attempt was made to keep some specimens alive from a series of about eighteen adults and a few nymphs taken in Canton on June 10, 1948. Several adults and the nymphs were placed with fresh *Polytrichum* in a plastic vial and taken home. A sod of the moss was also taken and placed on clean sand in an aquarium. This was watered well and a day later the lace bugs were placed on the moss. For the next day or two an occasional individual could be found apparently feeding on the fresh moss capsules from which the calyptra had fallen. This was also very definitely observed while the insects were being transported on the moss in the plastic vial. Later a nymph was seen in the process of molting to the adult stage. Due to unsatisfactory humidity or other conditions it was unable to successfully extricate itself, however. In a few days the insects disappeared entirely. If more specimens can sometime be obtained another effort will be made to rear them under conditions more nearly simulating the out-of-doors. The house in summer was probably too hot and dry.

Acalypta nyctalis Drake, 1928b, p. 5.

All that is known concerning this species is given in the paper cited above. It is described as ovate and yellowish brown. Although it resembles *A. lillianis* Bueno, this species may be distinguished by its much narrower paranota and by differences in the hood, carinae, and hemielytra. Two brachypterous females only are recorded. The holotype came from Franconia, New Hampshire, and is in the United States National Museum. The paratype was collected on June 1, 1924, in Alberta, Canada. They are 2.6 mm. long and 1.2 mm. wide.

Acalypta thomsonii Stål, 1873, p. 122.

Acalypta madelinae Bueno, 1926, p. 117.

Although this is the first American species described, it is rarely collected. It may be immediately separated from the two species previously mentioned by the low lateral carinae which diverge strongly behind. *A. thomsonii* is smooth, rather shiny and brownish to dark greyish brown. Only brachypterous individuals are known. Osborn and Drake (1916a) give the length as 2.5 to 3.0 mm. and the width as 1.5 to 1.75 mm.

Bueno (1926) cites three specimens sifted from leaves around the bases of alder clumps in a swamp by Mr. C. A. Frost in Sherborn and Framingham, Massachusetts. In the United States National Museum there is a specimen from Rhode Island (*fide* Sailer). Elsewhere the species occurs in Maryland (*fide* Sailer), South Carolina, Virginia, and the District of Columbia (Drake, 1928b).

Mr. Frost made his sifting collections in October, which means the insects were probably hibernating. A Virginia record for September 28 and a January 23 record for Maryland are both from *Sphagnum* moss (*fide* Sailer). Blatchley (1926) says they occur in late autumn beneath weed debris along the margins of swales. And Drake (1928b) states that adults hibernate in moss.

Genus *Leptopharsa* Stål, 1873

Leptostyla Stål, 1873; *Gelchossa,* Kirkaldy, 1904.

More than sixty species of this large and variable genus occur in South America and thirty-three in North America. Few are found elsewhere. Only three of the North American species have been reported from New England. They feed mostly on leguminous plants, but there are some interesting exceptions noted in the literature. Their elongate sub-rectangular form makes them readily

distinguishable from other local genera. There is a small areolate hood at the anterior end of the median carina which covers only the occiput. Lateral carinae are present and, like the median, have a single row of areolae. The membranous paranota are flaring erect. The hemielytra are constricted near the end of the abdomen and extend well beyond the terminalia. Areolae of the costal area are conspicuously large and the discoidal area is somewhat depressed.

Leptopharsa clitoriae (Heidemann), 1911b.

Leptostyla clitoriae Heidemann, 1911b, p. 180, Fig. 4.
Leptostyla costofasciata Drake, 1916, p. 326, Fig. 1.

This species is readily separated from the other two by its relatively broader and shorter form. Of the three in New England, *L. clitoriae* alone has the costal area completely biseriate. It is also most distinctively colored and the nearly black pattern contrasts sharply with the discrete whitish areas of the paranota and the costal borders. The figure in Drake's paper (1916) is a good representation of the species. It is about 2.2 to 2.4 mm. long and about 1.1 to 1.2 mm. wide.

McAtee (1919b) reports the species from Massachusetts, but I can find no more definite indication of its occurrence there. Proctor (1946) lists it for Mt. Desert Island, Maine. The only New England specimens seen are about a dozen in the New Haven Experiment Station collection, all taken by Mr. J. P. Johnson in New Haven on September 24, 1942. This Connecticut material is the best evidence of its presence in New England. Outside of this region the range extends to Indiana, Arkansas, and South Carolina (McAtee, 1919b).

McAtee (1917a) reports the insect from *Clitoria mariana* L. and various species of *Lespedeza,* and *Meibomia* (now *Desmodium*). Heidemann (1911b) said his type specimens were found close to the ground on *Clitoria.* Blatchley (1926) notes that it may be found on such legumes growing along high wooded slopes. Another host is said to be *Lappula* (Boraginaceae) (*fide* Sailer). In Proctor (1946) the notation "On alder, which is its food plant" raises an interesting question. The same source gives July–August as the time when specimens were obtained. In the District of Columbia dates of collection range from June 26 to October 14 (McAtee, 1923). McAtee (*ibid.*) notes eggs on July 19 and saw the species *in copula* on July 26. He also states that they are attracted to light.

Eggs: Heidemann (1911a, Pl. 10, Fig. 6) described the eggs of *L. clitoriae* just before his description of the adult insect was published. The eggs are said to be about .5 mm. long. They are laid singly and with the abopercular end attached to the lower side of the leaf. The egg stands upright, is ovate, and tapers noticeably toward the point of attachment. It is black except for the abopercular end, which is whitish. The chorion is thick and hard. It is covered with numerous coarse granules. There is a rim at the opercular end with channeled chorial processes running vertically around the extension of this collar-like structure on its inner side and continuing onto the low, broadly conical operculum to its center. The processes may be noticed on the outside since they budge somewhat. The ripples thus formed are usually covered with a whitish substance. There seems to be no literature on the nymphs nor on the other biological relationships of this species.

Leptopharsa heidemanni (Osborn and Drake), 1916a.

Leptostyla heidemanni Osborn and Drake, 1916a, p. 238.

Van Duzee (1917) erroneously synonymized this species with *L. clitoriae* (Heidemann), which is very distinctive. *L. heidemanni* (O. and D.) is, however, very similar to *L. oblonga* (Say). It is slightly larger than *L. oblonga* and appears to be somewhat broader in proportion to its length. The head spines of *L. heidemanni* and the transverse costal nervures are dark, while the same parts of *L. oblonga* are distinctly white or colorless. In the costal region of *L. heidemanni* there may be a few extra areolae which make the margin irregularly uniseriate throughout, but the costal area of *L. oblonga* is very regularly uniseriate from the base of the wing to just beyond the apex of the discoidal area. Specimens before me show the hood of *L. heidemanni* to be somewhat shorter and broader, with only three areolae along the median ridge where *L. oblonga* has four. Seen together they are readily separated. *L. heidemanni* is 3.0 mm. long and 1.0 mm. wide.

This is a wide ranging species and has been commonly collected in Massachusetts, Connecticut, and elsewhere in New England. Records for the two states named are so numerous it seems unnecessary to list them (see Parshley 1917c and 1923 for some published records). Parshley (1920b) also reports the species from Woodford, Vermont, and there is a specimen in the Rhode Island State College collection from Kingston. There are apparently no records from Maine nor from New Hampshire. The species is known from

New York to Ohio (Hurd, 1946), from Arkansas and Louisiana (Blatchley, 1926) and from Missouri (Froeschner, 1944).

With one exception the food plant is always given as *Baptisia tinctoria* (L.) R. Br. My collections locally have always been from that herbaceous host which commonly shows severe feeding damage. The Woodford, Vermont, material mentioned by Parshley (1920b) was taken on alder. This should be compared with the Mt. Desert record for *L. clitoriae* (Heidemann) (Proctor, 1946). McAtee (1923) records the seasonal activity as extending from May 2 to October 10 in the District of Columbia. New England records run from May 29 (Natick, Massachusetts—*fide* Sailer) to September 16 (East Hartford, Connecticut—Parshley, 1923).

During June and July I have found nymphs and adults feeding on the under side of *Baptisia* leaves. The injured foliage is conspicuously whitened on the upper surface. The leguminous host grows commonly on dry soils and often along roadsides or woodland openings. Favored situations are often warm and dry in good weather, but there are usually trees and shrubs nearby which offer some shade during the day.

Weiss and West (1924) give a good account of the habits and early stages of *L. heidemanni* (O. and D.). Their paper is readily available, and, therefore, their notes on the biology of the species are quoted in full, but the detailed descriptions of the egg and nymphal instars are omitted.

> "In the central portion of New Jersey overwintering adults appear about the last week of May and persist in more or less plentiful numbers until about the middle of June. As a rule the adults inhabit the lower surfaces of the leaves and do noticeable feeding, causing white areas to appear on the upper surfaces. Eggs are deposited during the last of May and first part of June and the young nymphs become plentiful about the middle of June. By the last of June and first week of July many last stage nymphs are in evidence and adults issue shortly afterwards, becoming numerous from the beginning of the second week of July until the end of the month. There is apparently only one brood and the adults gradually disappear during August. The eggs are deposited singly, or in irregular groups of two or three, in the lower tissue of the leaf either near or away from the midrib. Each egg is embedded well in the tissue with the long axis of the egg parallel with the leaf surface and with only the truncated, oval end of

the neck of the egg visible as it projects slightly beyond or remains flush with the leaf surface. These oval ends resemble stomata somewhat and are similar in color to the leaf. After hatching the young nymphs appear to feed close to the midrib, assuming a position as a rule, parallel to this part of the leaf. As they become older they feed in colonies of 10 or 12 on the lower leaf surface, although many leaves may contain more and some only one or two nymphs. Usually both adult and nymphal feeding is well scattered over the plant. In severe infestations, which often occur, every leaf is white and hundreds of whitish nymphs and adults inhabit each plant. Such a condition existed at Prospertown, N. J., on July 18, when hundreds of adults and a very few last stage nymphs were observed on the whitened plants. Five nymphal stages were observed. . . .''

Leptopharsa oblonga (Say), 1825.

Tingis oblonga Say, 1825, p. 325.

Leptopharsa oblonga (Say) closely resembles *L. heidemanni* (O. and D.) except in the features mentioned under that species. It is included on the basis of specimens in the Museum of Comparative Zoology collection taken by Blanchard in Tyngsboro, Massachusetts, on March 17, 1895. This is the only record for the species in New England as far as I can discover. That early in the year they must have been in hibernation. Hurd (1946) gives the range as New Jersey to South Dakota to Arkansas to Virginia and Brazil. The species is about 2.8 mm. long and about .9 mm. wide.

Dates of collection for *L. oblonga* (Say) in the District of Columbia run from June 5 to August 22 (McAtee, 1923). Most food plant records are *Falcata comosa* (L.) (now *Amphicarpa bracteata* (L.)). Blatchley (1923) also gives *Amorpha fruticosa* L. and *Kuhnistera* (now *Petalostemum*) as hosts and states the insects were swept from herbage in dense upland woods. McAtee (1917a) reports specimens from a leaf of *Tilia* in Wisconsin and from *Petalostemum* growing on dry gravelly knolls in Iowa.

Genus *Galeatus* Curtis, 1833

Galeatus peckhami (Ashmead), 1887.

Sphaerocysta peckhami Ashmead, 1887, p. 156.

Galeatus peckhami (Ashmead) is one of the most unusual members of the New England tingid fauna. The paranota and the

costal area of the hemielytra have a single row of large subquadrangular areolae. The dorsal membranous parts are all hyaline except for some infuscation of the much inflated lateral carinae which rise above the median carina and the tumid apex of the pronotum. All nervures are yellowish brown. The hood is very small and does not cover the head, which bears five remarkably long, sharp, slender and erect spines. The body is reddish brown, while legs and antennae are yellowish. This species is 4 to 4.5 mm. long.

Parshley (1917c) gives Princeton, Maine (July 12, 1909), as one New England locality for *Galeatus,* while Proctor (1946) reports the species from Salisbury Cove on Mt. Desert Island in the same state (July 15), and there was a nymph from Bar Harbor, also on Mt. Desert, in the Museum of the Boston Society of Natural History. New Hampshire records include the Glen House (July 20, 1915) (Parshley 1917c) and Fabyans, also in the collection of the Boston Society of Natural History.

The type locality is in Wisconsin and the species ranges from Ontario to Manitoba in the north (Blatchley, 1926). Records from Michigan, Minnesota, and New York (Drake 1922c) are before me. Uhler (1896) recognized this species in material from Japan. However, his (Uhler, 1904) report of the species from New Mexico is not valid, since Horváth (1923) has described a new species based on the Las Vegas specimen.

Nymphs: Osborn and Drake (Drake, 1922c) found the species numerous and breeding on *Aster macrophyllus* L. and *Eupatorium* on the summit of Crataegus Hill, Barber Point, Cranberry Lake, New York, during the last week of July, 1920. At the time only adults were present, but the exuviae of four different nymphal instars were found clinging to the lower surface of aster leaves. The three later stage exuviae were nearly perfect and these are figured (Pl. 4, Figs. f, i, j) and described. The number of nymphal instars is probably five.

Eggs: Drake (1922c) says that:

> "The eggs of *Galeatus peckhami* (Ashmead) are almost entirely inserted in the stem of the host plant, usually somewhat near the surface of the ground, upon which the insects are feeding. They are generally placed singly (Plate 4, Fig. e) and in no definite order in the stems of the plants. Only a small portion of the egg or the neck-like structure and cap protrudes from the plant. However, occasionally two or rarely three eggs are inserted in the same slit or egg puncture. Sometimes five

or six or even a dozen may be laid in rather close proximity to each other. They are deposited during the latter part of July, August, and September. In proportion to the size of the abdomen the eggs are quite large and only a few fully formed ova can be contained within the body of the female at the same time. This probably accounts for the long period of egg-deposition. There is but a single generation a year in the Adirondacks and field observation indicates conclusively that eggs, which are laid in the latter part of the summer do not hatch until the following spring. Asters, in which eggs had been deposited in the stems in the field, were transferred to small pots and placed in the laboratory at Syracuse. Adult males and females were also carried to Syracuse on the host plants, but all died during the latter part of September and October. The plants were destroyed by mildew during November and December. The eggs, which had been deposited during July or later, failed to incubate in the laboratory, but seemed to have remained in a living state until they were destroyed by desiccation of the stems of the asters a few weeks after the plants had been killed by the mildew.

"The egg (Plate 4, Fig. e) is slightly curved, from .7 to .8 mm. long and about one-third as wide. The cephalic end is distinctly neck-shaped and closed by a round cap or lid. The color varies from brown to dark brown or black, usually considerably darker on the cephalic half and with a much lighter cap."

Adults: The genus *Galeatus* is predominantly Palearctic in distribution and in some species the hemielytral length is variable. Only macropterous individuals of *G. peckhami* are known, however. According to Drake (1928a) the species is locally distributed, but may be found in large numbers on knolls in semi-shady, dry situations. Four predaceous Heteroptera were found associated with *Galeatus* in the Cranberry Lake region. Whether or not the adults overwinter is unknown. Van Duzee (1889) recorded this insect as swept from low weeds, probably a dwarf vaccinium or a species of aralia, which were growing together among pines on a rocky island in Canada.

Bueno (1915) noted thirty specimens found in beach drift on the shore of Lake Superior in Michigan, which suggest a migratory movement over the lake. A good figure (Pl. 4, Fig. a) of the adult accompanies the paper by Drake (1922c).

Genus *Gargaphia* Stål, 1873

This genus may be readily separated from all others by the transverse carina that interrupts the rostral channel between the meso- and metasternum. In addition, it differs from the related genera *Corythaica* and *Corythucha* by having a much smaller hood that never extends beyond the anterior margin of the eyes, and from *Stephanitis* by its low median carina and flattened discoidal area. Fifty-five species, all from the Western Hemisphere, compose this genus. Twenty-six of these are from North America, and of these, only three are known from New England (Hurd, 1946).

Gargaphia angulata Heidemann, 1899, p. 301.

Gargaphia angulata Heidemann is the smallest of the three species occurring in New England. In this species the free rim of the paranota is about level with the crests of the pronotal carinae. In the other two the paranotal margin is noticeably higher. Hood, carinae, and paranota bear an abundance of long, silky setae. Except for the body, the dark disc of the pronotum, and the fuscous fourth antennites and tarsi, the color is dull stramineous. The insect is 3.4 mm. long and 1.6 mm. wide.

New England records are not numerous, and only two of the states are represented. Massachusetts records are from Framingham, June 15, August 30, and September 1, Mr. C. A. Frost, collector; Natick, June 4, *fide* H. G. Barber; and Westfield, July 10, (Parshley, 1917c). Connecticut records include Brookfield, July 27, (Parshley, 1917c); Hartford, June 15, New Haven, June 23, July 23, and August 19, New Haven Experiment Station collection. Hurd (1946) gives the full range for this species as Massachusetts to Colorado, Alabama to Minnesota.

Mr. C. A. Frost made his collections on *Ceanothus americanus* L. (Rhamnaceae), which, from several other reports (*e.g.*, McAtee, 1917b), seems to be the preferred host. The species first came to scientific notice, however, as a pest of beans (Chittenden, 1900). The paper just referred to has a good figure of *G. angulata* Heidemann. The same drawing was used later by Blatchley (1926). The season of activity in New England runs from about June 4 (*fide* Barber) to September 1 (*fide* Sailer). Although Mr. Frost has collected them in the vicinity of Framingham, Massachusetts, for several years, I have been unsuccessful in searching the same host in the Boston park system and in Dover. The distribution appears to be very local and there is no other biological data on record.

Gargaphia solani Heidemann, 1914, p. 136, figure 1.

The preference of *G. solani* Heidemann for solanaceous plants has given this tingid considerable economic importance. This is especially true in parts of its range where eggplants are grown commercially. The species is readily distinguished from *G. angulata* Heidemann by its larger size and from both *G. angulata* Heidemann and *G. tiliae* (Walsh) by its high-angled hood which is laterally compressed, by the lobes at the middle of the paranota which are wide and flaring-erect, and by the infuscated first, second, and fourth antennites, nervures of the paranotal lobes, and many nervures of the hemielytra. Hood, paranota, and pronotal carinae are conspicuously covered with long, soft hairs. They are about 4 mm. long and 2 mm. wide.

The only New England record discovered is for Milford, Connecticut (September 21, 1944), on eggplant (*fide* Sailer). The species is primarily southern and southwestern in distribution. Its known range includes Virginia (Fink, 1915), Maryland, Ohio, Arizona, Texas, and Missouri (Blatchley, 1926). Hurd (1946) also lists Canada.

Fink (1915) contributed importantly to our knowledge of the habits and life cycle of *Gargaphia solani* Heidemann. With the exception of a few host plant records and one or two other items, the following biological information is derived from his paper.

Eggs: The eggs are about .37 mm. long and .18 mm. wide. They are light to dark green where attached, but become brownish towards the opercular end. There is a whitish, lacy border around the cap and a screw-like rim. The operculum is said to be crater-like. The eggs are attached to the under side of the food plant leaves near their abopercular ends and usually lean in all directions and at many angles. They are laid in roughly circular masses of about 116 to 188 in all, over a period of five to eight days. A single female will oviposit on four or five days, laying from 15 to 57 eggs on each occasion, to complete the egg mass. After oviposition a sticky secretion is spread over the eggs. The female attends the eggs during the entire incubation period and leaves them only at intervals to feed. The incubation period for the eggs in late May, June, and July at Norfolk, Virginia, ranged from five to eight days.

Nymphs: The five nymphal instars are fully described by Fink (1915) and the final stage shown in his Pl. 1, Fig. 1. Maternal solicitude is an interesting phenomenon in the genus *Gargaphia.* The attendance of the female on the eggs is not peculiar to this

species nor is her subsequent care for the young unique. Bueno (1942) made similar observations on *G. iridescens* Champion in Arizona and noted that *G. tiliae* (Walsh) has been frequently seen watching over its nymphs. This I can confirm from local observations of the species last named. Fink (1915) points out that the nymphs always feed in groups. After the first molt they become yellowish and also move to new feeding positions. When they move from one leaf to another the female usually directs them and keeps the brood together with her antennae. With a colony of over one hundred to care for, the female moves hurriedly from one end of the migrating brood to the other in an effort to keep them together and to urge them on in the proper direction. Once the movement is satisfactorily completed, the nymphs settle down in the new area and begin to feed.

Not only does the female guide the activities of her nymphs, she also attempts to protect them from predators. On one occasion Fink (1915) saw a ladybird beetle (*Hippodamia convergens* Guer.) approach a feeding colony of nymphs. The adult in attendance suddenly darted toward the intruder with wings outstretched and somewhat raised. She actually succeeded in driving the beetle from the leaf.

During their growth the nymphs molt five times. Fink (1915) followed the development of nine individuals and found that two days was the usual interval between molts. Since the eggs require an incubation period of 5 to 8 days, and the nymphs take another 10 days to mature, he estimates that the life-cycle is usually completed in about 20 days. This makes some allowance for the time necessary for mating and oviposition.

Adults: Fink observed that females laid their first eggs as soon as two days after copulation. In the Norfolk, Virginia, area they have a breeding season of nearly six months, extending from late May into early November. There is a possibility of seven to eight generations each year in that area. In the field these generations overlap so that all stages may be found practically throughout the season. The insects feed naturally on such solanaceous plants as *Solanum carolinense* L. and *S. elaeagnifolium* Cav. (Heidemann, 1914). *S. Melongena* L. (Fink, 1915), *S. tuberosum* L., and *Lycopersicum esculentum* Mill. (Somes, 1916) are crop plants which attract this lace bug. Damage to eggplant is particularly severe and typical of tingid injury to foliage. This insect has been collected from such diverse hosts as *Amphiachrus* (possibly *Amphi-*

achyris Nutt. which is now *Gutierrezia* Lag., Compositae), *Cassia* species, Leguminosae, *Gossypium herbaceum* L., Malvaceae, and *Salvia Pitcheri* Torr. (now *Salvia azurea* Lam., Labiatae) (Gibson, 1919b).

The adults hibernate and emerge early to feed on *S. carolinense* L. Whereas six broods develop on the eggplant, probably seven or eight a season are produced on the native *Solanum* (Fink, 1915). Froeschner (1944) reports adults all year in Missouri, where they usually are found hibernating in grass clumps during the winter months, but may also be collected under bark or the basal leaf rosettes of mullein (*Verbascum*).

Fink's (1915) discussion of the predators of *G. solani* is of particular importance since the natural enemies of tingids are but rarely mentioned. He observed both larval and adult ladybird beetles of two species (*Hippodamia convergens* Guer. and *Megilla maculata* De Geer) feeding on nymphs and adults. Usually the beetles turned the lace bugs on their backs before feeding on them. The soldier-bug, *Podisus maculiventris* (Say), feeds on the nymphs, as does another common hemipteron, *Triphleps insidiosus* (Say) (now *Orius insidiosus* (Say)). In addition to these insects, three species of spiders feed on all stages. They are *Epeira domiciliorum* Hentz, *Plectana stellata* Hentz, and *Chiracanthium inclusum* Hentz. Many lace bugs were found decapitated and their bodies mutilated. A few specimens of a parasitic hymenopteron (*Microdus* sp.) were reared with the tingids, but it was not proved that they parasitized them. Artificial control on egg-plants can be effected with nicotine sulfate and fish oil soap sprays thoroughly applied to the under side of the leaves. Adults are not killed by the nicotine sulfate alone, but seven pounds of the fish oil soap in fifty gallons of water will kill all nymphs and 90 to 95% of the adults.

Gargaphia tiliae (Walsh), 1864.

Tingis tiliae Walsh, 1864, p. 408.

In addition to the differences already mentioned, *G. tiliae* may be distinguished from the two other species by its generally pale whitish color. Usually only a few nervures just beyond the middle of the discoidal area are infuscated enough to produce a spot on each hemielytron which extends onto the adjacent costal area. The pubescence of *G. tiliae* is less pronounced, which results in a neater appearance. There is, however, a fine, dense, and somewhat matted pubescence on the disc of the pronotum.

Rhode Island is the only New England state for which there seem to be no records. There are no published records for Maine and Vermont nor for New Brunswick and Quebec in eastern Canada. Specimens collected in those places, or to be found in other collections, will be noted. Four Maine localities can be reported. They are Paris (*fide* Sailer), Willimantic, Lambert Lake, and Albion (Bailey). Previously unpublished (see Parshley 1917c) New Hampshire records include Antrim (*fide* Sailer), Durham (University of New Hampshire) and Harrisville (Bailey). The only specimens seen from Vermont are some in my collection from Sunderland. Massachusetts stations not listed before are Montgomery (*fide* Sailer), Amherst (University of Massachusetts), Boston and Swansea (Boston Society of Natural History), Mt. Holyoke (Cornell University), Arnold Arboretum, Boxford, and Georgetown (Bailey). There is material in the New Haven Experiment Station collection from Canaan and from Salisbury. Although Provancher (1886) suggested that the species occurred in Quebec, no definite records were found. There are, however, specimens from that province in Professor Parshley's collection and the species was taken in Applegrove on September 1, 1949. There are also specimens in my collection from Richmond Center, New Brunswick. Beyond the limits of New England, *G. tiliae* ranges from New York to Ontario, Nebraska, Arizona, Missouri, Alabama, and Virginia (Blatchley, 1926 and Hurd, 1946).

Some notes on the life history and immature stages are given by Weiss (1919). The interest of the females in their eggs and young has already been discussed (see *G. solani*). Since there is nothing further to add, it need not be repeated. The habits of this species evidently follow the same pattern.

Eggs: The eggs are .48 mm. long and .18 mm. in diameter. They are sub-oval, since one side is more convex than the other. The basal portion is somewhat acute, but rounded at the tip and slightly constricted where it is inserted into the leaf. The opercular end is truncate and bears a rim-like collar. The operculum is conical and has a slight nipple-like projection in the center. Except that the upper third of the egg may be covered with the usual varnish-like secretion, the eggs are translucent. In Pennsylvania eggs are laid in late May and early June. They are deposited in groups of less than 60 to as many as 300 on the lower leaf surface. Most project at right angles to the leaf, but they may lean in any direction. The surface of the leaf above the egg mass usually be-

comes brown as a result of injury to the tissues. Incubation of the eggs takes about a week. Weiss (1919) observed two annual broods, with the second egg-laying period coming before mid-July.

Nymphs: Detailed descriptions of the five nymphal instars are given. Development of the nymphs is said to require about three weeks. The nymphs feed in compact groups with the female parent usually at hand. They are brownish white and, on the leaves somewhat discolored by their feeding injury, are rather inconspicuous. The upper surface of the damaged leaves becomes first mottled with whitened areas. These later turn brown as the tissue is killed and dries out.

Adults: The adults emerge from hibernation in late May or early June, feed on the linden foliage, and soon start to lay eggs. Early in the season the adults are scattered and the injury to the foliage is not very noticeable. About a month after the eggs are laid the first summer brood of adults appear. They continue the cycle by laying eggs before mid-July. These eggs produce the second brood adults by mid-August or early September. It is the adults of this second brood that hibernate to emerge the following spring.

All of the food plant records for this species are *Tilia*, except that Gibson (1919b) mentions wild cherry. *G. tiliae* has been so consistently associated with linden in most cases that the cherry record may be simply accidental. All of my collections and observations in the northeast have confirmed this host association. The approximate period of activity in eastern Massachusetts (Boxford) is indicated by collections at hand made on June 4, 1948, and September 3, 1948. The species is widespread and more prevalent than records suggest. It is very likely to be found wherever lindens will grow.

Genus *Corythaica* Stål, 1873

This genus is represented only in the Western Hemisphere. There are eight South American species, one from the Galapagos Islands, two in Central America, two in the West Indies, and four in North America (Hurd, 1945). Only one of these occurs in New England. Members of this genus have a prominent pronotal hood extending over the head beyond the proximal end of the third antennite. This one feature distinguishes *Corythaica* from all northeastern tingid genera except *Stephanitis* and *Corythucha*. From both of these genera *Corythaica* is separated by the narrow paranota and costal area, by the distal tapering of the hemielytra, by

the uniformly biseriate hypocostal ridge, and by the small size of our native species.

Corythaica bellula Bueno, 1917, p. 19.

Corythaica floridana Blatchley, 1926, p. 471.

The occurrence of *C. bellula* Bueno in the northeast is of considerable interest since the other members of the genus are largely restricted to milder climatic zones. Up until about 1947 the species was known only from the type locality in White Plains, New York, and from Florida (*C. floridana* Blatchley—see Drake, 1930). In White Plains, Bueno and Mr. C. E. Olsen (Bueno, 1917) swept them in some numbers from fine low grasses and moss on a meadow sloping up from a rich marshy swale. They were taken from April to September.

Our next information concerning this lace bug came from Miss Hilda Vilkomerson who was working on the cyto-genetics of *Panicum Lindheimeri* at Brown University. She found some insects associated with the *Panicum* collected in Pawtucket, Rhode Island, and causing enough damage to interfere with seed production. Some of these eventually were sent to Professor C. J. Drake and he identified *Corythaica bellula* Bueno. In response to a letter concerning New England Tingidae, Professor Drake informed me of this and suggested that the species should be found in Massachusetts. Acting on this suggestion, an effort was made to find *Corythaica* locally and the species was soon discovered to be rather general in distribution and, in some places, fairly abundant. My first success came in Canton on July 26, 1948. A few days later a pair was taken in West Newbury. About a week later a nymph and an adult were swept from *Panicum* growing on a wood road in Dover. During the remainder of the season seven more collections were made at the Canton locality, yielding a total of over 30 specimens. In all cases *Panicum* was the chief element in the low herbs swept. The last specimen of the 1948 season was actually taken by shaking a tuft of *Panicum* over the palm of my hand.

The next season the first two adults were taken in Canton on June 1. Nymphs were found there on June 10 and other nymphs and adults were subsequently collected. Another locality was added on July 7 when teneral adults were swept from *Panicum* on the shore of a pond in Milton.

However, of greatest interest during the 1949 season was a successful attempt to rear *Corythaica*. Three clumps of *Panicum*

were brought into the greenhouse from the Canton station and potted up after weeding out other grasses. This was done on June 13. Plants A and B were fairly large, showed signs of previous feeding injury (a mottled whitening of blades), and had nymphs present when potted.

When examined on June 20, there were still nymphs on Plants A and B and four adults were also seen. On June 22 six adults were counted on Plant A and five on B. A pair were observed in copulation on this date and another pair on June 27. While mating the male is nearly at right angles to the female. His wing tips are above hers, and the tip of his abdomen is beneath her wing tips. As the male retracted his aedaegus after separating from the female, he appeared to push it first with the tip of one clasper and then with the other. The female of this pair was still somewhat teneral.

Plant C was small and showed no signs of injury. It appeared to be quite free from infestation. On Plant C two pairs of *Corythaica bellula* were placed on June 21, and the pair seen copulating on June 27 was added on that date. A large lamp chimney with fine copper screening at the upper end was put over the plant. On July 29 the plant was thinned out considerably and in the process nymphs in various stages were seen and eggs located in the grass blades. Only two adults could be found. On August 4 Plant C was again examined and eight adult males were collected. Five of the eight were very teneral and the other three probably somewhat so. Many nymphs were still present. These results prove concluclusively that *Corythaica bellula* Bueno can complete its development on *Panicum* and, with the other evidence noted, indicate that the grass is the natural host of this species. Since the period from June 21, when pairs of adults were first placed on Plant C, to August 4, when teneral adults were first observed, is 44 days, the life cycle of the species is completed in six weeks at the most and probably in a somewhat shorter time.

My collections to date tend to show that *Corythaica bellula* Bueno may be found almost anywhere that the *Panicum* will grow. Bueno's note on the type locality was given above and the wood road station in Dover, Massachusetts, mentioned. The only things the situations I have collected them in seem to have in common are the presence of the *Panicum* and the possibility of some shade. Since there is considerable variation in the amount of shade available, the *Panicum* is actually the only common factor. However, it may be of some value to describe the range of habitats. In the

Canton station the *Panicum* grows in small openings between such trees as *Prunus serotina* Ehrht., *Betula populifolia* Marsh., *Acer rubrum* L., young *Pinus Strobus* L., *Pinus rigida* Mill., *Juniperus virginiana* L., *Comptonia peregrina* (L.) Coult., *Vaccinium* and *Quercus* species, and other vegetation. Often the *Panicum* grows from a lichen mat around the edges of these areas and with other sparse grasses (*e.g., Danthonia spicata* (L.) Beauv.) along the bridle trails. In mid-summer the station, though low, is often rather dry and hot. Some of the most heavily infested plants were in the full shade of young pines whose lower branches are only about 3 to 4 feet from the ground. West Newbury specimens came from grasses along the edges of a ploughed field with a dense shrub border and trees just beyond. Other new records include Errol, New Hampshire (September 9, 1949), where they were picked by hand from small clumps of *Panicum* on the gravelly shore of a small pond surrounded by shrubs on the bank; Dummer Hill, New Hampshire (September 10, 1949), where eight adults (some teneral) were shaken from *Panicum* growing in low dense herbs at the edge of a large field; Eaton Center, New Hampshire (September 11, 1949), where about fourteen adults were taken from *Panicum* growing in the gravel between the road pavement and a pond. Other New Hampshire records are for Harrisville (August 14 and 15, 1950). Nymphs and adults were found on small *Panicum* plants growing in the crevices of granite ledges with lichens on a wooded hillside. On August 5, 1950, a Connecticut record was added when nymphs and adults were collected in East Hartland on *Panicum,* again growing from granite crevices and along paths where the soil nearby was moist enough to support a lush growth of *Vaccinium corymbosum* L., *Acer rubrum* L., some *Kalmia latifolia* L., and other vegetation. Strangely enough, there was a ploughed field just beside the area covered with shrubs and trees which was carpeted with a rank mat of what appeared to be the same *Panicum.* In the freshly turned soil the growth was much more luxuriant. Sweeping those plants in the open field gave no specimens, however. My earliest record is May 14, 1950, for West Newbury and the latest is a Canton record for September 26, 1948. Although collecting was started on April 25, 1950, in Canton, no specimens were taken there until June 16, 1950. Nymphs have been taken from June 10 until August 15 in central New England. It is probable that the adults hibernate, but they have yet to be collected in winter.

Eggs: The eggs are .54 mm. long and .13 mm. wide. They are colorless, smooth, and sub-cylindrical. There is a slight curvature

on the long axis and the abopercular end is bluntly rounded. The female inserts them between and parallel to the longitudinal veins of the *Panicum* blade from either the lower or upper side. Only the operculum protrudes beyond the epidermis of the leaf. A constriction and ring-like thickening mark the area of opercular attachment at the leaf surface. The opercular end is bent somewhat to bring it above the leaf surface. The cap itself bulges slightly at the base above the point of constriction and then tapers from its base to a low, somewhat striated, and rounded peak. The striated appearance is due to the alveolar nature of the opercular tissue. The eggs are apparently laid singly and in no particular relation to one another. One or several may be found in a grass blade.

Nymphs: The characteristic form of a late nymphal instar is well shown in Fig. 2 (drawn by Mr. F. Y. Cheng). The nymphs are broad in proportion to their length and rather flat dorso-ventrally. The dorsal surface of living nymphs has a greyish lavender tone and a shagreened texture. This apparent roughness results from the numerous short white stellate hairs scattered generously over the surface beneath the larger, more conspicuous, branching spines which are arranged in a rather definite pattern. The earliest instars are paler. Cotton (1917) gives a good account of *Corythaica monacha* Stål, a pest of egg-plant in Porto Rico. For this species he describes five nymphal instars, and his data show that the cycle from egg to adult may require only 15 to 17 days. He also notes two species of coccinellid beetles and two reduviid bugs as predators.

Adults: Corythaica bellula Bueno differs so much from all other New England tingids that it is easily recognized. The hood is low, flat, and broadly rounded behind, and tapers to a sharp point forward where the apex curves down over the front of the head. The pronotal carinae are all membranous and uniseriate. Paranota are narrow and erect. The costal area has a single row of rather large areolae and the hypocostal ridge has two rows of small areolae. The median nervure of the hood is carinate and nearly black, as are most of the hemielytral nervures. All areolae are greyish white and opaque. Hood, carinae, paranota, and costal area are colorless, giving this minute insect a striking appearance. Both brachypterous and macropterous forms are known, but the latter are uncommon and I have not yet seen a macropterous specimen from New England. Hurd (1945) gives a figure (Pl. 1, Fig. 2) of the short-winged form. Macropterous individuals are 2.2 mm. long

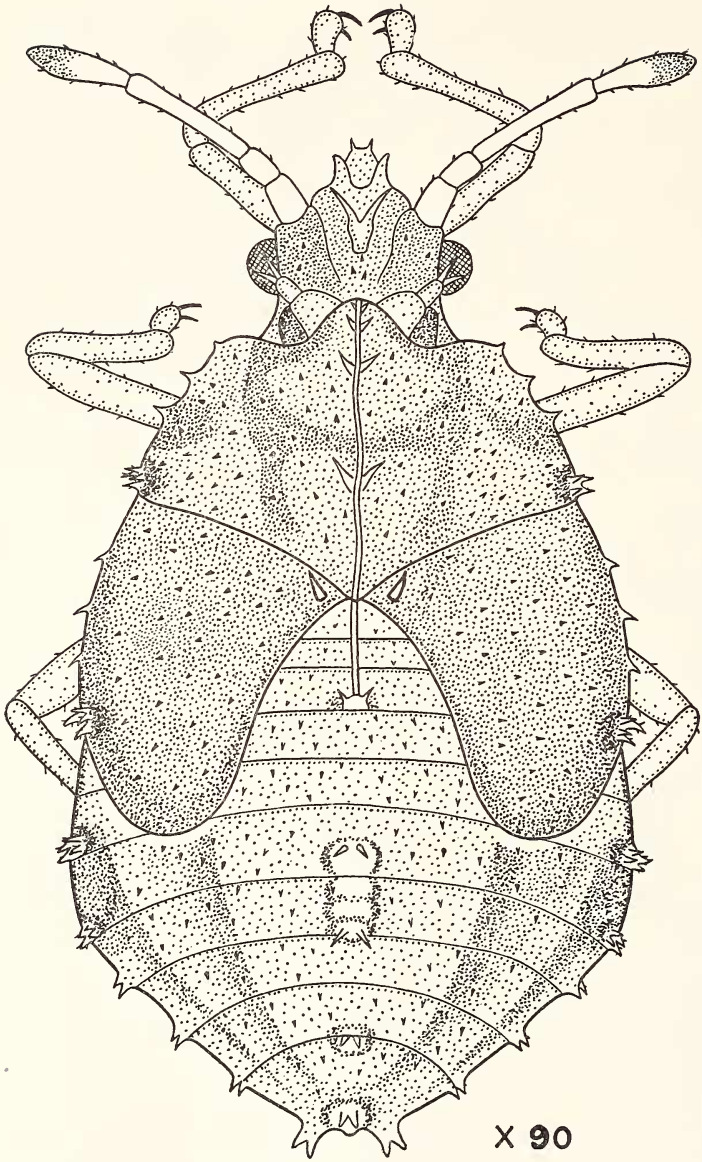


Fig. 2. Late nymph of *Corythaica bellula* Bueno. Drawn by Mr. F. Y. Cheng.

and brachypterous forms 1.98 mm. long. Both forms are .8 mm. wide.

Genus *Stephanitis* Stål, 1873

The species in this genus are predominantly Palearctic in distribution. Of the five now known to occur in North America, two were evidently introduced from Japan and a third is native to eastern North America (Weiss, 1918b). Only these three species will be found in New England. One of the three, *Stephanitis globulifera* (Matsumura), is apparently a recent introduction and this is the first account of its occurrence in North America.

Members of the genus are easily distinguished from representatives of the related genera in this area. In our species of *Stephanitis* the hood covers the head, the rostral sulcus is not interrupted, and the discoidal area of the hemielytron is raised. These features distinguish them from the New England species of *Gargaphia,* in which the hood does not cover the head, the rostral channel is interrupted, and the discoidal area is not elevated. From *Corythaica, Stephanitis* species are distinguished by their greater size, their wider and nearly erect paranota, their high arched median carinae, and by their more rounded hoods. Finally they differ from *Corythucha* species principally in their more erect, less broadly rounded paranota, in the narrow, evenly curved humeral angle of their hemielytra, and in the much greater length of their antennae.

Stephanitis globulifera (Matsumura), 1905.

Tingis globulifera Matsumura, 1905, p. 36, Pl. 19, Fig. 16.

In studying a collection of Tingidae from the New Haven, Connecticut Agricultural Experiment Station, two somewhat damaged specimens of an unfamiliar *Stephanitis* were noted. Since no description of the species could be found in the literature dealing with American species, they were sent to Dr. Reece I. Sailer for determination. They proved to be *Stephanitis globulifera* (Matsumura) when compared with specimens in the National Museum. The species was first described by Matsumura as *Tingis globulifera* in 1905. Later Horváth (1912) properly transferred it to the genus *Stephanitis* and redescribed it in some detail. In a 1930 publication Matsumura supplied an English translation of the description which is not very satisfactory and a very small, unsatisfactory figure is also given. Since these three references are not generally available, it seems desirable to include a brief comparative description of this recent addition to our insect fauna.

The two specimens mentioned above were sent to the Experiment Station by Mrs. L. B. Winton of Greenwich in late October, 1946. Therefore, correspondence was initiated to gather more details of their occurrence. Mrs. Winton kindly kept me well informed concerning the appearance and development of the population in her garden during the summer of 1950. However, it was after mid-August before many adults were observed. On August 23 I visited her garden and found a heavy infestation of nymphs and adults (mostly somewhat teneral) on a splendid specimen of *Pieris japonica* (Thunb.) Don, planted in a sheltered corner between the house and an open porch. More than 150 adults were collected in a few minutes and a score or so more were kept alive for further study.

Mrs. Winton reported that the lace bugs were first troublesome on the *Pieris* in 1945. By the following year they were destructively abundant. For a time she considered removal of the host plant because it was so seriously injured by them. However, by frequent spraying, continued intermittently even throughout the mild winter of 1949–50, the population was somewhat controlled and the plant was still vigorous at the time of my visit.

The late appearance of the adults suggests that this species overwinters in the egg stage, as do the other two species of *Stephanitis* that occur in New England and that also infest members of the plant family Ericaceae. Of added interest is the fact that *Stephanitis pyrioides* (Scott) was collected on a deciduous azalea on the opposite side of the house. This species was not found on *Pieris*. However, a few specimens of *S. globulifera* were associated with *S. pyrioides* on the azalea. Such other ericaceous plants as *Kalmia* and *Rhododendron* in her garden supported no lace bugs at that time.

It is evident that this recently introduced species may become a serious pest of *Pieris* and possibly of other ornamental Ericaceae. Through Dr. C. L. Remington I learn that for two or three years the nurserymen of Fairfield County, Connecticut, have complained of serious damage to *Pieris* by lace bugs. Since other species are not known to feed on that host, it is apparent that *S. globulifera* is already well established. At this time it is only possible to suggest that eggs of the species were probably introduced before 1945 in the foliage of evergreens shipped from Japan or elsewhere. Mrs. Winton knew of infested plants in four or five gardens within three to eight miles of her home. She thought these infestations were probably of earlier origin than the one on her *Pieris*.

The following notes provide criteria for the identification of the three species of *Stephanitis* now established in the northeast. Both *S. pyrioides* (Scott) and *S. globulifera* (Matsumura) may be readily distinguished from *S. rhododendri* Horváth by their somewhat greater length, by their darker hood and hemielytral markings (which become intensely black in *S. globulifera*), by their much more inflated hoods (again extreme in *S. globulifera*), and by their much abbreviated lateral carinae. The paranota of *S. rhododendri* flare conspicuously. This species also differs from both the other species in the greater width of the hemielytra and in the abundance of silky setae on all the nervures of the membranous parts. The hypocostal ridge of the hemielytron of *S. rhododendri* is mostly biseriate and partly triseriate. It is uniseriate in the other two species.

The differences between *S. pyrioides* and *S. globulifera* are less obvious, but, nevertheless, pronounced. The most noticeable distinguishing features include the conspicuously dark color pattern of *S. globulifera.* In this species the entire hood of mature specimens is black. All the pronotal (including paranotal) nervures, except the apex of the median carina, are black, as are most of the hemielytral nervures. Areolae of the hood, the discoidal, and the sutural areas are fumeous, as are the cells of the basal and apical bands. Although the color pattern of *S. pyrioides* is similar, the paranota and the discoidal elevations are nearly colorless and in all areas the coloration is brownish and much less intense. Only the areolae of the hemielytral bands are fully infuscated.

Interesting differences are seen in the relative proportions of the hoods and pronotal carinae of these two species. In *S. globulifera* the much inflated, globose hood is twice as high at its peak as the crest of the median carina, while in *S. pyrioides* the hood and carina are sub-equal in height. Both species have the lateral carinae much reduced in length as compared with *S. rhododendri.* However, in *S. globulifera* they are half again as long as the distance between their anterior ends and the back of the hood, while in *S. pyrioides* they are about as long as the distance between their anterior ends and the back of the hood. In *S. globulifera* the hood is much wider than the distance between the lateral carinae, while in *S. pyrioides* the hood is only slightly wider. Both species have the paranota almost vertical rather than flaring as in *S. rhododendri.* Although differences in the relative lengths of the antennites and differences in other features can be shown, they are slight and those indicated are adequate for the ready separation of the

three species now occurring in New England. *S. globulifera* (Matsumura) is 3.7 to 4.0 mm. long and 2.0 mm. wide.

Stephanitis pyrioides (Scott), 1874.

Tingis pyrioides Scott, 1874, p. 440.
Stephanitis azaleae Horváth, 1905, p. 568.

As previously indicated, *S. pyrioides* is readily distinguished from *S. rhododendri* by its much larger globose hood and by its uniseriate hypocostal ridge. From *S. globulifera* it is easily separated by its paler color, by the sub-equal height of the hood and median carina, and by the smaller hood that is only slightly wider than the distance between the lateral carinae. This species is 3.6 to 4.0 mm. long and 2.0 mm. wide.

Records for *S. pyrioides* are relatively few and scattered. This is a very typical situation, which reflects more accurately the distribution of collectors than of the insects. There was a specimen in the collection of the Museum of the Boston Society of Natural History from Pocasset, Massachusetts, and in my collection are specimens collected in Newton Centre on August 15 and October 29, 1949. In the Rhode Island State College collection there is one taken in Kingston. On August 23, 1950, I made a collection in Greenwich, Connecticut. Other records for that state are for New Canaan on September 10 and 20 and for Hamden on August 15.

S. pyrioides (Scott) is a native of Japan (Scott, 1874; Uhler, 1896; Drake, 1923) and was introduced in the egg stage on azaleas imported from that country (Weiss, 1916a and 1918a). It is now locally abundant in New Jersey (Barber and Weiss, 1922), and is known from Pennsylvania and the District of Columbia (Blatchley, 1926). Froeschner (1944) found it also in Missouri. The species has also become established in Holland (Dickerson and Weiss, 1917).

All of the host records are for azaleas, and both the evergreen and deciduous kinds, as well as hardy and greenhouse varieties, are susceptible to infestation. My Newton Centre specimens were found on *Rhododendron calendulaceum* (Michx.) Torr., an American deciduous azalea. They were plants set out several years ago, and the lace bug infestation is of fairly recent origin. Weiss 1918b) records *Azalea indica* (*Rhododendron indicum* Sweet) and *Azalea amoena* (*R. obtusum* Planch. var. *amoenum* Rehd.), both semi-evergreen forms, as the hosts. He states (see also Dickerson and Weiss, 1917) that infestations on the deciduous varieties are

not as severe as on the evergreen kinds. This is undoubtedly related to the fact that *Stephanitis pyrioides* (Scott) overwinters in the egg stage. Since the eggs are deposited in the leaves, they probably have a better chance of surviving the winter in the living leaves on the plants than in fallen leaves that, under garden conditions, are likely to be raked up and destroyed. This, in part, may also account for the relative rarity of the species in New England, since the evergreen azaleas are near the limit of their hardiness and are not too commonly grown. Dickerson and Weiss (1917) record the following species of azalea and their hybrids and varieties as susceptible to infestation: *Rhododendron molle* Don and *R. schlippenbachii* Maxim., both deciduous; *R. mucronatum* Don and *R. yedoense* Maxim., both semi-evergreen, and *R. ponticum* L., an evergreen species.

As usual, the tingids live on the under side of the leaves. Nymphs and adults pierce the leaves and destroy the mesophyll which results in a blanching and browning of the upper surface. In heavy infestations the leaves are dried out and many drop during the summer. The lower leaf surface is also mottled with the excrement of the lace bugs.

The early stages and life cycle were studied in some detail by Dickerson and Weiss, and a good account with an excellent plate, showing egg, nymphal instars, adult, male terminalia and parts of the female external and internal genitalia, is given in their paper (1917). Some of their findings are quoted below.

Eggs: The eggs are 0.4 mm. long and 0.18 mm. wide. They are smooth, white and flask-shaped, with the opercular end bent to one side. Since they are inserted in the leaf tissue along the mid-rib and larger veins, the curved neck brings the cap just above the lower leaf surface. Each operculum resembles an oval or irregularly circular whitish disc. They are sometimes covered with a brownish, crust-like deposit. One to ninety eggs may be found in a single leaf. Usually the younger leaves are chosen by ovipositing females. Most are placed irregularly along the mid-rib. The eggs overwinter and in southern New Jersey hatch towards the end of May. By late June adults appear and lay eggs that hatch in about two weeks. In late July and early August, second brood adults appear and another two week period of oviposition follows. These produce a third generation of adults by late September, and during early October they lay the eggs that will overwinter.

Nymphs: Five nymphal stages occur. The length of each in-

star varies from three to six days (Weiss, 1918b). The average time for development from egg to adult in southern New Jersey is only a month. As the figures show, the nymphs are elongate oval and bear conspicuous spines dorsally and at the posterior dorsolateral angle of each abdominal tergite.

Adults: As noted above, three generations appear each season in southern New Jersey. At the peak of each cycle of adult abundance the proportion of males and females is about equal. Females, however, seem to live longer than the males and the former are always more numerous during the egg laying periods. The last brood adults may be found until late in November and these lingering individuals are usually females. The males apparently die soon after copulation.

The deposition of a single egg takes the female two to three minutes. She pushes the ovipositor from its sheath and touches the surface of the leaf until she locates a satisfactory position. Then the ovipositor is thrust into the leaf tissue until the abdomen comes to rest against the leaf and is then withdrawn.

On account of the several extended periods of oviposition, all stages may be found together from late June until October. In central New Jersey two full broods and a partial third one develop. Further north the season is shorter and the cycle probably takes longer. This also accounts in part for the smaller populations that occur in central New England.

Stephanitis rhododendri Horváth, 1905, p. 567.

Leptobyrsa explanata Heidemann, 1908, p. 105, Pl. 4. Figs. d, e, f.

This species is at once distinguished from both the others occurring in New England by the irregularly biseriate hypocostal ridge. This structure is uniseriate in the others. Horváth (1905) described the insect from cultivated rhododendrons growing in Holland and observed that it had been introduced into Europe. This view is supported by others (Dickerson, 1917), although the fact that tingid eggs have been found on rhododendrons imported from Holland (Weiss, 1915) may have led some to the erroneous belief that this lace bug was introduced into the Atlantic states from Europe (Blatchley, 1926). On August 5, 1950, I collected them on native *Kalmia latifolia* L. in East Hartland, Connecticut, where infestation from cultivated plants was most unlikely. Such evidence, coupled with the marked structural differences between

S. rhododendri and the two established Palearctic species, points to eastern North America as the place of origin of this species.

There are records from all of the New England states except Vermont. It is the species of *Stephanitis* most commonly collected. Parshley (1917c and 1923b) has published numerous Massachusetts and Connecticut records which suggest a general distribution. The few Maine records include Bar Harbor (*fide* Sailer), Southwest Harbor (Proctor, 1946), both on Mt. Desert Island, and Orono (Parshley). There are specimens in the University of New Hampshire collection from Durham. The Rhode Island State College collection contains specimens from Kingston and Newport. The range extends from New England west to Ohio and south to Florida. In actuality, it is likely to be found wherever rhododendrons are grown since it is commonly distributed in the egg stage with nursery stock.

Like other species in the genus, the host plants are all Ericaceae. The native *Kalmia latifolia* L. and *Rhododendron maximum* L. are the hosts usually recorded and the plants from which my collections have been made. Barber and Weiss (1922) report *Kalmia angustifolia* L. as another host. White (1933) observed that plants fully exposed to the sun were most heavily infested and most seriously injured. He adds *Pieris japonica* (Thunb.) Don and *Pieris floribunda* (Pursh) B. and H. to the list of hosts. Dickerson (1917) quotes from Dutch sources that the species has been found on 120 varieties of rhododendrons and azaleas.

Our present knowledge of the biology of *Stephanitis rhododendri* Horváth results primarily from the studies of Heidemann (1908), Crosby and Hadley (1915), and Dickerson (1917). The following account is based on their papers. Each of these publications contains plates of significance. Some of their figures are reproduced in the articles by Weiss (1918b) and by Barber and Weiss (1922) which summarize their contributions.

Eggs: The egg is ovoid-cylindrical in shape with the opercular end slightly constricted and bent to one side. They are smooth and yellowish white. The length is about 0.4 mm. and the diameter about half the length. The operculum is oval and makes the end obliquely truncate, whereas the opposite end is rather evenly rounded. Most of the eggs are laid in irregular rows along the mid-rib. Some may be found inserted in the other large leaf veins or even in the blade a few millimeters from any vein. They are always laid on the lower side of the leaf and the younger leaves are

selected (see Crosby and Hadley, 1915, Pl. 22, Figs. 2 and 3, Pl. 23, Fig. 2; Dickerson, 1917, Pl. 8, Fig. 6). The leaf cells surrounding the eggs become corky and form a small gall-like mass that may be easily separated from the normal tissue. The egg cap is level with the leaf surface and, as is usual among the Tingidae, the females deposit a brownish substance that forms a varnish-like scab over the eggs. This crust often peels away before the eggs hatch. Few to as many as 176 eggs may be counted in a single leaf, but the number laid by a single female has not been ascertained. In laying the egg the abdomen of the female is parallel with the leaf and the extended ovipositor is driven backward and ventrally into the leaf. The eggs of this species overwinter in the evergreen foliage of the host plants.

In the District of Columbia, Heidemann (1908) found unhatched eggs and recently hatched nymphs on April 20. In New Jersey (Dickerson, 1917) they are said to emerge in early May. In Ithaca, New York, they hatch in late May and early June (Crosby and Hadley, 1915). Egg laying probably starts in late June and continues through July. There is evidence that the eggs hatch over a prolonged period since nymphs are sometimes seen in early August. In New Jersey two broods may develop. There is need for clarification of such details.

Nymphs: Most notable is the fact that this species apparently has only four nymphal instars. This is an exceptional condition among the Tingidae, where five usually occur. Heidemann (1908) has described the last stage and figured a nymph (Pl. 4). Crosby and Hadley (1915) figure the four instars (Pl. 23) and describe them in detail.

They describe hatching in the following manner:

> "In hatching, the end of the egg enlarges slightly, becoming almost transparent. Then the nymph gradually emerges, the red eye-spots showing very conspicuously. The body sways back and forth slowly, during emergence, with slight spasmodic movements. When all the body has emerged except the last two or three segments, the spines along the sides of the body and the legs stiffen out. Then the leaf surface is grasped by the claws of the legs, and the insect is able with this help to withdraw the body entirely. Often the egg shell is drawn partly out of its pocket by this last effort. The newly emerged insect rests for several minutes after its exertions, then it slowly walks around, seeking a suitable feeding place. When

first emerged the nymph is colorless, almost transparent, except for the bright red eyes. Soon after feeding commences, it begins to darken up.

"The nymphs feed in groups, remaining in a place a short time, then moving to a new location. The characteristic feeding attitude is with the body inclined upward towards the head, the antennae straight outward slightly diverging. At intervals the body sways slightly from side to side. After feeding a short time, the proboscis is withdrawn, and the slender inner sucking tube is carefully cleaned with the forefeet, in much the same fashion as the ordinary house fly."

Under insectary conditions in Ithaca they found that the length of the various nymphal stages was as follows:

"First stage, 6 to 7 days;
Second stage, 4 to 6 days;
Third stage, 3 to 6 days;
Fourth stage, 12 to 15 days."

They also suggest that development may require somewhat longer out-of-doors. Their observations give a minimum time of 25 days and an average of about 30 days for that region. In New Jersey, Dickerson (1917) found that some nymphs completed their growth in only twenty days. This supports his view that two broods may mature there and further south.

Dickerson (1917) observed that the first three nymphal instars stay together and move very little, but the final stage nymphs move about more freely. He also noted that the rostral sheath doubles on itself when the insects feed and the tip of the beak guides the extended lancets.

Adults: The feeding of adults and nymphs causes the usual mottled whitening of the upper leaf surface characteristic of lace bug injury. In heavy infestations the leaves become dry and shriveled. This makes the plants unsightly in the garden and may hinder the sale of nursery stock. The under side of the leaves becomes thickly dotted with the rusty brown excrement of the feeding bugs.

Adults have been collected from June 6 to September 2 in Connecticut. In favorable seasons their period of activity probably somewhat exceeds those limits. Specimens have been taken in Princeton, Massachusetts, as late as October (*fide* Sailer).

Stephanitis rhododendri Horváth is usually a little shorter than the other two species and varies from 3.3 to 3.7 mm. long. It

is, however, somewhat wider because the hemielytra are unusually broad beyond the discoidal area. They are about 2.4 mm. in width. Heidemann's figure of the adult (1908, Pl. 4, Fig. d) is an excellent representation.

Dickerson (1917) gives one of the first and one of the few descriptions of tingid external genitalia. He figures (Pl. 8) the male terminalia from the dorsal (Fig. 1) and ventral (Fig. 2) aspects, the ventral aspect of the three sternites of a female showing the ovipositor in position (Fig. 3), the ovipositor in transverse section showing the inter-relationship of the valves (Fig. 4), and a greatly magnified view of the serrated element of the ovipositor that makes the incision in the leaf tissue (Fig. 5).

Genus *Corythucha* Stål, 1873

All members of this large genus are restricted to the Western Hemisphere. About sixty-three species and a few varieties have been described (Hurd, 1946). Of this number, fifty-one are North American, and of the fifty-one, fifteen species and one variety are found in New England. Many of the species are strikingly similar and, as a group, show evidence of close relationship. Professor Parshley (1923b) pointed out that our knowdelge of the limits of variation within any one species is far from adequate. This is still true and, because of their close affinities the species are, in some cases, difficult to identify. Although several species seem to have very specific food habits which aid in their identification, if host records are available, such evidence can be misleading since other species are less selective and since recent observations will show that the same species may have different host preferences in different parts of its range.

Species of *Corythucha* are among our commonest tingids. Since they are gregarious, their feeding damage is often conspicuous and announces their presence on a variety of common native and cultivated plants. Accordingly, some of them are frequently collected. However, the biology of some of the most common species has been neglected, and there is much we could profitably learn about their habits and the ecological factors controlling their distribution. The New England species usually live on the under side of the leaves of trees and shrubs but a few live on herbaceous plants. As far as we know they all overwinter as adults under loose bark on trees, amongst fallen leaves, and under stones or other shelter.

The genus *Corythucha* is readily distinguished from other local forms. Only three genera represented in this region have large pronotal hoods covering their heads. In addition to *Corythucha,* these are *Corythaica* and *Stephanitis.* From *Corythaica bellula* Bueno, our only native species, *Corythucha* is readily distinguished by the hood which is distinctly globose posteriorly, by the broadly rounded paranota, by the strongly constricted and reflexed humeral area of the hemielytra, and by the larger size of all local species. *Corythucha* differs from *Stephanitis* also in the humeral hemielytral constriction and reflection, in the marked constriction and forward projection of the hood which reaches beyond the base of the third antennite, and in the more broadly rounded, medially bullate paranota. *Corythucha* species are sub-quadrangular in outline, which increases their distinctiveness. Uhler (1886), Provancher (1886), Banks (1910), Blatchley (1926), and others commonly misspelled the generic name *Corythuca,* leaving out the final h.

Corythucha arcuata (Say), 1832.

Tingis arcuata Say, 1832; in Fitch reprint, 1858, p. 794; Say (in LeConte edition), 1859, p. 349.
Corythucha mali Gibson, 1918, p. 98.
Corythucha arcuata var. *mali* Drake, 1921, p. 54.

Froeschner (1944), Dr. Sailer (letter), and I are agreed that, since all gradations from the typical *C. arcuata* (Say) color pattern, with a full basal and apical bar, to the extreme *mali* pattern, with the apical bar entirely lacking and other markings reduced, may be collected at one time from the same oak tree, there is no valid reason for using a varietal name. Blatchley (1926) gives the range of this species as New England and Quebec west to North Dakota and Colorado and south to Texas and Alabama. Froeschner (1944) lists Missouri stations, and specimens have been seen from Virginia. Parshley (1915) lists three localities for Maine, and to the three mentioned Albion (September 8, 1949) should be added. His (1917c) New England records give two for New Hampshire (Durham and Hampton), numerous Massachusetts and Connecticut localities, and Kingston, Rhode Island. Another addition seems to be the first for Vermont. Specimens were found on *Quercus Prinus* L. on August 31, 1949, in Wells. This lace bug probably occurs, usually on members of the white oak group, throughout this region. On the campus of the University of Massachusetts, Morrill (1903) found *Quercus alba* L., *Q. Prinus* L., *Q. rubra* L., *Q. Muehlenbergii*

Engelm. heavily infested and a light infestation on *Q. macrocarpa* Michx. However, other oaks growing nearby, in some cases with their branches touching infested trees, seemed to be quite immune from attack. These species were: *Quercus coccinea* Muenchh., *Q. ilicifolia* Wang., and *Q. laurifolia* Michx. Drake (1928a) states that they occasionally breed on chestnut and very rarely on maple and apple. *Quercus prinoides* Willd. is also mentioned as a host (*fide* Sailer).

The season of activity is suggested by Massachusetts records which extend from May 20 (Bailey) to October 9 (Bueno, 1924a). For the District of Columbia the period lasts from May 2 to November 21, and McAtee (1923) observed pairs mating as late as September 27. Bueno (1924a) found an oak in Amherst, Massachusetts, heavily populated with eggs, nymphs, and adults on October 9. They hibernate beneath leaves and in other sheltered places on the ground (Drake, 1928a).

In his paper describing the immature stages of *Corythucha arcuata* (Say), Morrill (1903) set a fine example for subsequent studies of the Tingidae. A splendid plate of the egg and five nymphal stages is included (Pl. 3). There are, however, many gaps yet to be filled concerning details of the life cycle of this species.

Eggs: The eggs of this species are noticeably tapered at the basal end, but are otherwise of the usual sub-cylindrical shape. They are about .56 mm. long and the greatest diameter is .24 mm. There is a narrow collar at the apical end on which the operculum rests. The cap itself is a low cone with fifteen to twenty ridges converging from the base to meet at the apex. There may be a slender filament of variable length rising from the apex where the ridges meet. It is commonly one-fifth as long as the egg. The eggs are smooth and shiny black. They generally are covered with a dark rough coating that may be easily rubbed away. Eggs are laid on the lower side of the leaves and may be found from late May (Morrill, 1903) until early October (Bueno, 1924a) in Massachusetts. They are usually laid in roughly circular patches in which the individual eggs are well-spaced. The eggs are often near the larger leaf veins but may be anywhere on the leaf blade. Single eggs are found, but as a rule the clusters contain twenty-five to fifty, and over one hundred may be counted on a leaf. Each female probably lays many eggs, but no definite figures are available. The late copulation mentioned by McAtee (1923) suggests that impregnated females may hibernate and lay their eggs the following spring. The incubation period of the eggs is not established.

Nymphs: Morrill's full descriptions and figures (1903) of the five nymphal instars make any detailed account unnecessary. Like other tingid nymphs, those of *C. arcuata* feed in groups. As they move around on the lower leaf surface they deposit shiny black excrement in dots. Their feeding results in a whitening of the upper leaf surface. As is usual in heavy lace bug infestations, the foliage injury may be very conspicuous and seriously detracts from the appearance of the plant. The early stadia last two or three days, but from six to seven days pass between the fourth and fifth moults. It therefore takes at least eighteen days for the nymphs to mature and may take twenty-four. In central New England the early summer brood probably matures in thirty or forty days. Whether or not another generation develops before late fall has not been determined.

Morrill (1903) found nymphs of a predaceous heteropteron very active in destroying the young nymphs of *C. arcuata.*

Adults: Since adults of our New England species of *Corythucha* may be identified by use of the key given previously, only a few of the more striking features will be mentioned in the discussion of the species. The few details given here should not be considered adequate for determination of the species. In many cases host records are useful indicators, but any species may at times be collected from plants on which it does not breed nor even feed. Therefore, even the host records of careful collectors should not be relied on completely.

Four species in this region have the hood and median carina sub-equal in height. *C. arcuata* (Say) is somewhat smaller than the other three. One of the greatest differences is seen in the external male genitalia (see Figs. 5A, D, and E, and Fig. 6G). The figures are all on the same scale and it is immediately obvious that the genital capsule of *C. arcuata* is only about half as large as any of the other three. There are also differences in the actual form of the hood and in other features. In both *C. caryae* sp. nov. and *C. pruni* O. and D. the hood is appreciably larger and more broadly globose and flattened behind. Spines on the hood nervures are few in *C. caryae* and practically absent in *C. pruni.* The hood of *C. ciliata* (Say) is noticeably broader and slightly flatter than that of *C. arcuata.* The whitish opacity of the hood nervures and areolae of *C. ciliata* and the numerous black-tipped spines on the nervures also differentiate it from all other species. *C. arcuata* (Say) is 3.0 to 3.3 mm. long and about 1.6 mm. wide.

Corythucha associata Osborn and Drake, 1916b, p. 14.

Corythucha spinulosa Gibson, 1918, p. 79.

The only New England state from which this species is now known is Connecticut. Localities are sufficiently numerous (New Haven Experiment Station and Parshley collections) to suggest the general occurrence of *C. associata* O. and D. in that state. Records available for Connecticut range from May 27 to September 23. McAtee (1923) gives records for the District of Columbia ranging from May 18 to October 2. The species is found from New York to Ohio and Indiana and south to Mississippi and Georgia (Monte, 1940). *Prunus serotina* Ehrh. is the host for this species (Osborn and Drake, 1916b and Drake, 1928a).

Under the name of *C. spinulosa* Gibson the early stages of this species are described and some biological information given by Dickerson and Weiss (1918). A plate (7) showing the egg, five nymphal stages, the adult, and feeding injury to the cherry leaf accompanies their paper. Their study is the source of the following details.

Eggs: The eggs are about .55 mm. long and are .2 mm. wide. They are sub-elliptical. The basal half is translucent and the apical half is dark brown. The end attached to the leaf is acute, but the tip is rounded. There is a slight tapering toward the truncate apical end, which has a collar-like rim and a low cone-shaped operculum. In New Jersey females emerge in early June, feed, and soon begin to oviposit. By June 20 most of the eggs have been laid and the females have mostly disappeared. The eggs are usually inserted irregularly in and along the mid-rib on the lower side of the cherry leaf. Most project almost parallel to the leaf surface, but some are perpendicular to the blade and a few may be placed at an angle in the mid-rib tissue. Only the rounded abopercular end is inserted into the leaf. The exposed part of the egg is covered with the black varnish-like excrement of the female. From 4 to 35 eggs may be counted on a single leaf, but the average number is about fifteen. Eggs start to hatch about June 25 and by July 15 adults are seen again. Incubation of the eggs takes two or three weeks.

Nymphs: Full descriptions of the five instars and a figure of each are given by Dickerson and Weiss. Each of the first three stadia lasts two or three days, the fourth takes three or four days, and the fifth requires seven to nine days. The minimum time for development from egg to adult would be about thirty days and the

maximum probably about forty days. Depending largely on temperature, the life cycle would require four to six weeks.

The nymphs feed in the usual groups and preferably close to the mid-rib. If scattered they will soon reassemble. The last two instars tend to be a little more independent. By late July most of the first brood nymphs are mature.

Adults: There are nine species of *Corythucha* in New England with hoods twice as high as the median carina. Three of the six have very small hoods and extremely low carinae and would, therefore, never be confused with the others. The three with small hoods and low carinae are *C. mollicula* O. and D., *C. pergandei* Heidemann, and *C. ulmi* O. and D. The small size of *C. bellula* Gibson, *C. coryli* O. and D., and *C. marmorata* (Uhler) (from 2.8 to 3.4 mm. long) immediately distinguishes them from *C. associata*. *C. pallipes* Parshley is most like *C. associata* in size and in hood form. However, the areolae of the hood of *C. pallipes* are less than half as large as the cells of the hood of *C. associata* and the nervures of the latter are much embrowned, while the nervures are pale in *C. pallipes*. A comparison of Fig. 5B and Fig.6E will reveal differences in the male genitalia. Adults of *C. associata* measure about 4.0 to 4.2 mm. in length and are 2.4 mm. wide.

They feed on the under surface of the leaves with the nymphs and cause a whitening of the central part of the blade along both sides of the mid-rib on the upper surface. In New Jersey adults of the first brood begin to appear in abundance by late July. By the end of August second brood adults are found and they continue to develop well into September. It is this generation that later hibernates.

Corythucha bellula Gibson, 1918, p. 93.

This small species somewhat resembles *C. coryli* O. and D. and is also closely related to *C. hewitti* Drake. It may be distinguished from the former by its slightly larger size, by the much smaller hood areolae, and by the more conspicuous spots on the paranota. From *C. hewitti* it differs in having shorter marginal spines, a more angulate and narrowed hood and in usually having some large hyaline areolae in the apical band (Drake, 1918). In all these features there is considerable variation and the specimens from northern New England suggests that these two species should be studied further for clarification of their specific limits. Males of the specimens from Maine have a larger genital capsule and their claspers are stouter and blunter than in males of *C. coryli* from Massachusetts

(Figs. 5B and F). They are about 3 mm. long by about 1.7 mm. wide.

My collection contains material from Harvey, New Brunswick; East Brighton, Vermont; Daigle, Houlton, Madrid, Moose River, and Pleasant Landing, Maine. They were collected from September 2 to 9 in 1949. The host plant in all cases was *Corylus*. Outside of New England published records include New York and Ohio (Hurd, 1946). The type specimens were found on *Crataegus* (Gibson, 1918). Drake (1928a) reports the following plants as hosts: *Crataegus succulenta* var. *neofluvialis* (Ashe) Palmer, *C. punctata* Jacq., *C. pruinosa* (Wendl.) K. Koch (Rosaceae), *Alnus incana* (L.) Moench (Corylaceae), and *Ribes oxycanthoides* L. (Saxifragaceae). In the same paper he states that adults hibernate in bark crevices and among fallen leaves. In New York they are active from May into September. No other biological information is available.

Corythucha caryae sp. nov.

This lace bug from hickory resembles *Corythucha pruni* O. and D. in the shape of its hood and superficially resembles both *C. arcuata* (Say) and *C. ulmi* O. and D. in the lack of an apical hemielytral band. *C. caryae* is a little larger than the last two species named and it differs from both in having a larger, broader hood that is noticeably flattened. The hood of *C. caryae* is very slightly higher than the crest of the median carina. Although the hood of *C. ulmi* O. and D. is small, it is about twice as high as the median carina. Males of *C. caryae* (Fig. 5D) are easily distinguished from *C. arcuata* (Say) (Fig. 5A) by the much larger genital segment and both sexes are distinguished by the large areolae of the hood and the whitish opacity of the paranota of *C. caryae*. *C. pruni* O. and D. is appreciably larger than *C. caryae* and the hood of the former is smoother, almost spineless, and much less sharply constricted. In *C. pruni* O. and D. the hood areolae are somewhat clouded with yellowish brown and the nervures are all amber. The hood areolae of *C. caryae* are sub-hyaline and a few nervures of the crest are dark brown, the rest pale amber. Males of *C. caryae* (Fig. 5D) are at once separated by their claspers, which taper to a rather acute point while the claspers of *C. pruni* O. and D. (Fig. 6G) have almost spatulate tips.

The antennae of *C. caryae* are more or less densely clothed with bristly hairs of various lengths. On the terminal antennite the

bristles are especially short and numerous, giving the tip a tufted appearance. Antennite one is barely twice as long as antennite two and, except where it tapers proximally, of the same diameter as the second. Antennite three is more slender and much longer than the others. It is twice as long as antennite four, which is clavate and broadest distally. The rostrum extends just beyond the meso-metasternal groove and reaches the hind coxae. The sternal ridges have a single row of conspicuous hyaline areolae set off by stout brownish black nervures. The greatest width of the hood is 0.6 mm. and it is 0.9 mm. long. It is constricted rather abruptly to less than half its greatest width anterior to the middle, and rather abruptly tapers at the tip. A few short spines occur on the nervures of the hood, especially on the sides of the constricted portion. The posterior part is sub-globose and noticeably flattened dorsally, which gives this species a resemblance to *C. pruni* O. and D. The areolae of the hood are more than twice as large as those of the paranota. The paranota are evenly areolate and bordered by sharp, black-tipped spines, some of which also occur on the nervures of the upper surface. The anterior and posterior margins are strongly raised and the mid-area of the paranotal membrane is bullate. The pronotum and the base of its triangular process are punctate. The posterior portion of the process gradually approaches an areolate condition. The lateral carinae are highest anteriorly and the 3–4 areolae become increasingly smaller posteriorly. The median carina is foliaceous, slightly raised anteriorly, but slightly lower than the crest of the hood. It consists of a single row of areolae with a partial second row beneath and just behind the large anterior cell. A few spines occur on the nervures of the carina and sides and apex of the hood. The apex of the hemielytron is evenly rounded and the lateral margins are sub-parallel. Areolae of the costal area are in four rows and are small from the posterior margin of the basal cross-bar forward. Behind the bar there are three rows and the cells rapidly become much larger. The subcostal area is triseriate and the areolae are very small except posteriorly, where a single row of appreciably larger areolae occurs. The humeral elevations are a little lower than the crest of the median carina. Spines along the costal margin of the hemielytra become increasingly shorter from the proximal end towards the distal and are entirely absent on the posterior third of the wing. Males are 3.4 to 3.7 mm. long and females are 3.4 to 3.8 mm. long. Males vary in width from 1.87 to 2.0 mm. while females are from 1.9 to 2.2 mm. in width. The

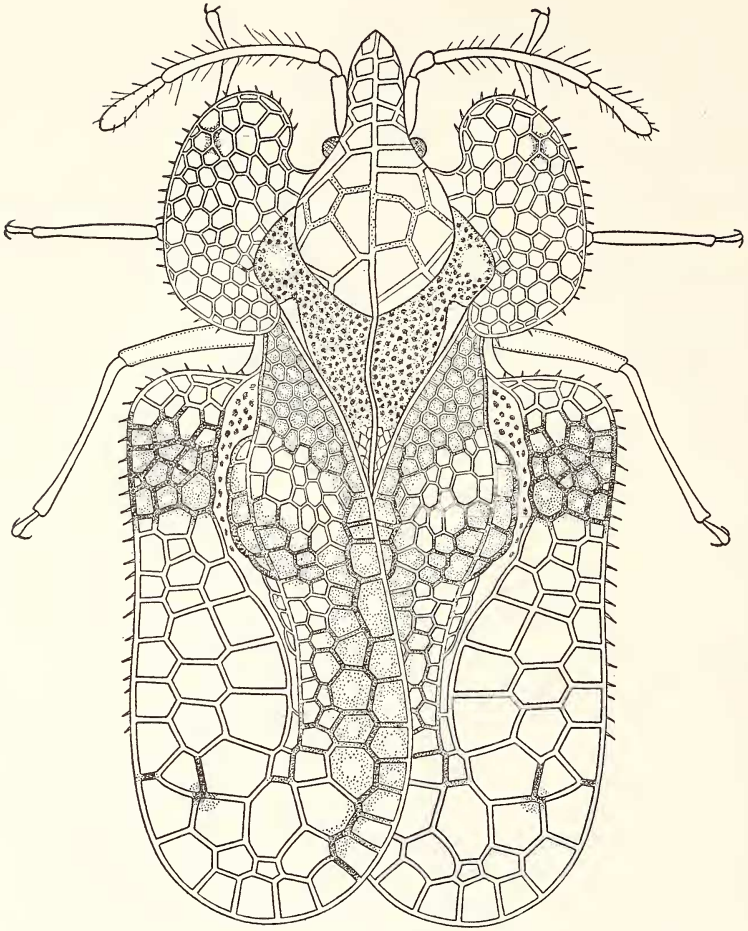


Fig. 3. *Corythucha caryae* sp. nov. Drawn by Mr. F. Y. Cheng.

average male is about 3.4 mm. long and the average female is about 3.55 mm. long. These measurements are based on thirty males and thirty females selected at random from the type series.

Color: A few nervures of the crown of the hood are somewhat embrowned. The hood areolae are sub-hyaline. The paranota have a small brown spot anterior to the tumid center and the areolae are mostly whitish and sub-opaque. The pronotum is dark brown, with a varnished look over the disc, but becoming almost white at

the apex of the triangular process. A few central nervures of the median carina are embrowned. The hemielytra have a single bar just behind the anterior margin. Areolae anterior to the bar are sub-opaque. Areolae and nervures of the bar are fusco-testaceous. The discoidal and sutural areas are also embrowned nearly to the apex, except that the anterior portion of the discoidal elevations has hyaline areolae and pale nervures. The sub-costal area is colorless except in the region of the basal band. The areolae of the costal area and the apical margin are distinctly hyaline. There is no apical band, but a few nervures near the posterior union of the costal and subcostal areas may be darkened. Without magnification the cross-shaped pattern of the dorsal markings is rather striking. Antennae and legs are amber, while the rostrum and tarsi are slightly darker. The ventral side of the body is black, except for some reddish amber areas about the caudal end. I am indebted to Mr. F. Y. Cheng for Fig. 3 which is an excellent representation of this species.

The first specimens seen were given to me by Dr. William L. Nutting, who had collected them on young hickories in a Salem, New Hampshire, field in July of 1946. Since that time I have collected the same species on various occasions from July 13 to September 6 in the towns of Georgetown, Newbury, and West Newbury, Massachusetts (Essex County). They have always been found on hickories (probably *Carya ovata* (Mill.) K. Koch). There are specimens in my collection taken during each of the last four seasons. On March 25, 1948, a single adult was found in hibernation under the exfoliating bark on a hickory trunk. Early stage nymphs were numerous on July 13, 1950, and in 1948 a few late instars were found on September 6. A lot of about 250 adults collected on *Carya* in Newbury on August 7, 1950, is herein designated the type series. The holotype (a male) and an allotype from this series will be deposited in the Harvard Museum of Comparative Zoology. Paratypes will be placed in the United States National Museum collection. Numerous paratypes and topotypes remain in my collection and some of these will gladly be distributed on request.

On August 22, 1947, specimens were taken in Newbury (near Byfield Center) and several of them had mites attached. Some of these were sent to Dr. Edward W. Baker at the United States National Museum. He kindly identified them as larval Erythraeidae of the genus *Leptus,* which are known to be insect parasites in the larval stage and free living predators in the nymphal and adult

stages. Other instances of mites on tingids will be occasionally noted.

Corythucha ciliata (Say), 1832.

Tingis ciliata Say, 1832; in Fitch reprint, 1858, p. 793; Say (in LeConte edition), 1859, p. 348.

Gibson (1918) states that *C. ciliata* (Say) may be found on the sycamore tree (*Platanus*) wherever it grows east of the Rocky Mountains. This species differs from all others in the area in the whitish opacity of all the areolate areas. The concolorous pattern is complete, except for a brown patch on the medial posterior aspect of the discoidal elevations. Short black-tipped spines are numerous on the dorsal nervures. In *C. ciliata* the hood is small, somewhat flattened and sub-equal with the median carina in height. Its areolae are only a little larger than those of the paranota. The external male genitalia (Fig. 5E) are large and the bluntly rounded tips of the claspers separate this species from all except *C. pruni* O. and D. In *C. pruni* the clasper tips are decidedly spatulate (Fig. 6G). *C. ciliata* is about 3.75 mm. long and 1.6 mm. wide.

Parshley (1914) notes that the species has been collected in Maine. There seem to be no New Hampshire records, but a heavily infested sycamore was seen while driving through South Lee on September 11, 1949. On August 31, 1949, specimens were collected on *Platanus* in Wells, Vermont. Massachusetts and Connecticut records are fairly numerous (for some of them see Parshley 1917c and 1923b). There are a few specimens from Kingston in the Rhode Island State College collection.

Drake (1919a) reports that both nymphs and adults of this species have been collected on *Fraxinus, Carya ovata* (Mill.) K. Koch and *Broussonetia papyrifera* (L.) Vent. in Missouri. In the same state Froeschner (1944) records adults from cypress. A note on Dr. Sailer's list gives the interesting information that on April 5, 1949, Mr. Roy Latham found adults abundant on *Chamaedaphne* growing in a Long Island, New York, cedar swamp. *C. ciliata* (Say) is almost invariably found on mature sycamores no matter how isolated they may be from other trees of the same genus.

This constant association is probably favored by the nature of the sycamore bark, which exfoliates in large irregular pieces. As the outer bark gradually loosens, it offers apparently ideal shelter for hibernation, and overwintering adults may be found in abundance under the loose bark of such trees from October until as late

in the spring as early June in central New England. Froeschner (1944) says they also hibernate under logs, under the bark of other trees and in grass clumps. To such situations, McAtee (1923) adds among old leaves and on the foliage of scrub pine in the District of Columbia.

Massachusetts records at hand run from mid-March until early October. The extremes mentioned are records for hibernating adults. The duration of their seasonal activity will correspond closely with the period in which the trees are in leaf. By midsummer most sycamores show obvious feeding damage. The leaves become much whitened except around the margins. Some may wilt, turn brown, and even fall prematurely. Despite the abundance of this rather common species, the life cycle has not been studied in any detail.

Eggs: Heidemann (1911a) says the eggs are hidden in the pubescence on the leaf. Barber and Weiss (1922) state that the egg bases are inserted into the tissue along the larger veins and their forks on the lower side of the leaf. They are said to occur singly or in groups of no more than ten.

Nymphs: Morrill (1903) showed that each of the five nymphal stages could be distinguished from the corresponding instars of *C. arcuata* (Say). Barber and Weiss (1922) suggest that nymphal development takes about three weeks in New Jersey. They estimate that maturation from egg to adult requires about five weeks and that probably two broods develop annually.

Osborn and Drake (1917a) state that the adults are parasitized by a red mite. Parasitic mites were noted for *C. caryae* and for *Piesma cinerea* (Say) and other instances will be cited below. Weiss (1913) found that hibernating adults placed in a warm room demonstrate a strong negative geotropism. They will climb up on twigs or anything else available.

Corythucha coryli Osborn and Drake, 1917a, p. 299.

Five of our New England species have high-crested globose hoods about twice as high as the median carina. In addition to *C. coryli* O. and D., they are *C. pallipes* Parshley and *C. associata* O. and D., *C. bellula* Gibson and *C. cydoniae* (Fitch). *C. coryli* is at once distinguished from the first two species by its small size. This is reflected in the relative size of the male genital capsule of *C. coryli* (Fig. 5F) which should be compared with that of *C. associata* (Fig. 5B) and that of *C. pallipes* (Fig. 6E). The male genitalia of *C. cydoniae* are appreciably larger (Fig. 5G) and the

claspers of *C. bellula* males are much blunter (Fig. 5C). This species is usually smaller than any other in this region, being only 2.8 mm. long and 1.5 mm. wide.

No one has yet described the early stages of *C. coryli* O. and D. We know only that the usual host is reported as *Corylus americana* Walt. Mr. Nathan Banks has collected the species in Holliston, Massachusetts, on *Corylus* (Museum of Comparative Zoology). These, and the records below, are the only ones available for New England and are all from this state. McAtee (1923) records it from Maryland and Virginia, while Blatchley (1926) gives the range as from New Jersey and Maryland west to southern Indiana.

There are specimens at hand from Groveland and Georgetown from *Corylus*. However, it is of particular interest to record *Ostrya virginiana* (Mill.) K. Koch as a host. The hophornbeam is another native plant in the family Corylaceae. Dr. John T. Woodland brought me specimens from Stoneham which he had taken on this plant. Since then we have collected them on the same host in the Arnold Arboretum, Forest Hills, and in Stony Brook Reservation, Hyde Park. There are also specimens at hand from a roadside tree in the town of Newbury (Bailey). That *Ostrya* is a true host is indicated by the fact that eggs and the various nymphal stages have been taken along with numerous adults. The collections known cover the months from late May until mid-September. Early stage nymphs were collected on July 22 and late stages occurred until September 10. In the Stony Brook Reservation some plants of *Corylus* occur under the mature trees, but no lace bugs have been found on them. My only specimens from *Corylus* came from plants growing along the roadside, where they were fully exposed to sunlight.

On a few specimens from the Arnold Arboretum large ovoid mites were found. The mites were attached to the abdomen on the dorsal side beneath the wings. They have yet to be identified, but are larger and unlike any other that I have found on lace bugs.

Corythucha cydoniae (Fitch), 1861.

Tingis cydoniae Fitch, 1861, p. 114, Fig.
Corythucha arcuata Comstock, 1879, p. 221.
Corythucha arcuata crataegi Morrill, 1903, p. 132.
Corythucha crataegi Osborn and Drake, 1916a, p. 229.

In Massachusetts *C. cydoniae* (Fitch) is one of the commonest and most abundant tingids. Like *C. coryli* O. and D., the hood of this species is more than twice as high as the median carina. While

small, *C. cydoniae* averages somewhat larger than *C. coryli* and the cells of its hood, though large, are also somewhat smaller than the hood areolae of *C. coryli.* Another marked difference is seen in the general infuscation of the hood and the central area of the paranota. *C. cydoniae* is more completely and intensely pigmented than other New England species of *Corythucha.* The external male genitalia of *C. cydoniae* are appreciably larger than those of *C. coryli* (Figs. 5F and G). *C. cydoniae* (Fitch) is about 3.2 to 3.5 mm. long and about 1.7 to 2.0 mm. wide.

Although Monte (1940) and Hurd (1946) say this species is distributed generally throughout the United States, some qualification of such statements is probably desirable. Records for Massachusetts are so numerous and scattered that there is no doubt of its general occurrence in this state. Professor Parshley (1923b) indicates the same for Connecticut, and specimens in the New Haven Experiment Station collection support him. However, the only specimens seen from northern New England are a few from Durham in the University of New Hampshire collection. On my 1949 collecting trip through Maine, New Hampshire, and Vermont, not a single specimen was found although the usual host plants are fairly common in those states and even locally abundant. While driving in New Brunswick, for example, a hillside for some distance along the highway was covered with clumps of *Crataegus.* But there were no tingids on them. In the northeast this species is apparently not common north of Massachusetts.

Eggs: In his description of the eggs of this species, Professor Comstock (1879), on advice from Professor Uhler, referred them to *Corythucha arcuata* (Say). Morrill (1903) in his noteworthy paper pointed out that differences in the eggs alone were enough to distinguish the two and proposed a sub-specific name. For some time the fact that Fitch (1861) had already made a distinction between these species was overlooked or disregarded.

Comstock (1879) described the eggs as smooth, whitish, glistening and semi-transparent. They are ovoid and their broad ends are somewhat inserted into the leaf tissue. The female covers them with a brown, sticky substance that soon hardens and adheres so firmly to the upper part of the egg that it cannot be removed without crushing the egg. The opercular end of the egg is sharply truncate, which gives each egg the appearance of a small cone (*ibid.,* Pl. 4, Fig. 3). The round opercular openings make it easy to distinguish the empty egg shells from unhatched eggs. They are

usually laid in groups of from ten to thirty along the sides of the more prominent veins on the lower side of the leaf. In my experience, as many as 100 eggs may be counted on a single leaf and 40 or more frequently occur, as shown by the following observations.

I. Eggs of *Corythucha cydoniae* (Fitch) on *Amelanchier* leaves at Stony Brook Reservation, May 16, 1949.

Leaf 1 carried a total of 12 eggs.
" 2 " " 4 eggs.
" 3 " " 65 eggs.
" 4 " " 104 eggs.
" 5 " " 100 eggs.
" 6 " " 17 eggs.

In all 302 eggs were found, an average of about 50 to a leaf.

II. *Amelanchier* leaves with eggs taken June 1, 1949.

Leaf 1 with 1 mass of 22 eggs.
" 2 with 1 mass of 61 eggs.
" 3 with 2 masses of 32 and 15 eggs.
" 4 with 1 mass of 3 eggs.
" 5 with 1 mass of 60 eggs.
" 6 with 2 masses of 40 and 6 eggs.
" 7 with 3 masses of 24, 45 and 35 eggs.
" 8 with 2 masses of 22 and 43 eggs.
" 9 with 1 mass of 14 eggs.
" 10 with 1 mass of 57 eggs.
" 11 with 3 masses of 29, 15 and 14 eggs.
" 12 with 1 mass of 16 eggs.
" 13 with 1 mass of 12 eggs.
" 14 with 1 mass of 13 eggs.
" 15 with 1 mass of 48 eggs.
" 16 with 1 mass of 3 eggs.
" 17 with 1 mass of 48 eggs.
" 18 with 1 mass of 10 eggs.
" 19 with 1 mass of 50 eggs.
" 20 with 1 mass of 36 eggs.
" 21 with 3 masses of 14, 82 and 14 eggs.

In all 883 eggs were found, an average of about 42 eggs to a leaf.

My notes show that eggs are most abundant from mid-May until mid-June, but some may be found until nearly the end of August. Comstock (1879) states that living eggs may be found in

dead leaves under the bushes in winter. Adults, however, are known to hibernate and it is doubtful if any eggs survive.

The incubation period and other details have not been accurately determined. However, in 1950 the first eggs were observed on May 27 and the first nymphs were seen on June 17. Early in the season incubation takes three or four weeks, but the period is probably shortened by warmer weather then or later in the summer.

Nymphs: Comstock's (1879) few remarks concerning the nymphs are also of interest. He compares their dirty brownish color to the color of the material applied over the eggs and the slightly lighter color of the leaves injured by their feeding. Their bodies are broadly oval and flat and spines project from all parts. My field notes record first instar nymphs by early June and various stages may be found more or less abundant until late September. Details of nymphal anatomy and development have yet to be studied for this common species.

Adults: The plants on which *C. cydoniae* (Fitch) is most commonly found in abundance are all in the family Rosaceae. In this family species of at least six genera serve as the usual hosts. Fitch (1861) based his description of this tingid on specimens he received from Leominster, Massachusetts. His correspondent reported that quince trees (*Cydonia*) were being seriously damaged by heavy infestations of the lace bugs. Locally they have been found abundant and breeding on garden varieties of *Chaenomeles,* native and cultivated *Amelanchier, Crataegus,* and *Sorbus* (*Pyrus americana* (Marsh.) DC. and *P. Aucuparia* (L.) Gaertn.), and on wild *Pyrus melanocarpa* (Michx.) Willd. In the Parshley collection there are some with the host label "elderberry." Specimens in the United States National Museum were collected from loquat, *Malus,* pear, and *Pyracantha coccinea* Roem. (*fide* Sailer). McAtee (1917b and 1923) reports *Cephalanthus occidentalis* L. (Rubiaceae) as a host. Bueno (1933) swept them from *Quercus.* The food plants of *C. cydoniae* are unusually varied even if we consider only the rosaceous kinds as true hosts. My records for 1949 and 1950 show, however, that this species is reasonably selective even amongst rosaceous plants. During those two seasons regular collections were made from a bushy *Amelanchier* growing at the branch tips of a fairly large *Prunus serotina* Ehrh. On the same weekly visits *C. pruni* O. and D. was collected on the *Prunus.* During two entire seasons (see graphs) only two specimens of *C. cydoniae* were taken from the wild cherry—one female in 1949 and

a single male in 1950. Such evidence strongly suggests that records are accidental unless breeding populations are present on the plants in question.

Adults may be found hibernating in leaves on the ground (Drake, 1928a), under loose bark, and under sticks and stones (Comstock, 1879). They become active by mid-May, somewhat later than *C. pruni* O. and D., when the *Amelanchier* foliage is fairly well expanded in eastern Massachusetts.

As suggested above, this species and *C. pruni* were studied for two full seasons in the field. A station was chosen in the Stony Brook Reservation, Hyde Park, Massachusetts. This reservation is part of the Boston park system and supports a mixed hardwood stand. There are numerous small hills consisting basically of conglomerate outcrops. A fairly large pond, small streams, and swampy woods provide varied habitat conditions. The site chosen for convenience is near the edge of the reservation on the Hyde Park side. A wood road enters the reservation there. Along the road *Prunus serotina* Ehrh., *Vaccinium, Amelanchier, Rubus* and other shrubs and small trees grow. On each side is a low swale supporting a rank growth of herbs and various woody plants. A clump of *Prunus serotina,* a short distance in, served during both seasons as the collection station for *C. pruni* O. and D., since it had a heavy infestation of this tingid. At its branch tips a shrubby *Amelanchier* infested with *C. cydoniae* (Fitch) was a most convenient station for that species.

Collections were made regularly at weekly intervals for the two seasons. It was necessary to develop a technique that would give comparable results and not critically deplete the populations of the two tingids. After brief experimentation in the early spring of 1949, it was found that a small vial of alcohol could be easily held under the leaves and the insects flicked into them. Vials with plastic caps proved very satisfactory. They are $1\frac{3}{4}$ inches deep and $\frac{3}{8}$ of an inch in diameter at the top. Separate vials were used for each species and for each collection. The specimens could then be studied when convenient. The time limit set for each weekly collection at each plant was five minutes. At the height of their abundance as many as sixty were taken in the time allowed. This time limit seemed to give a reasonable indication of population density without depleting the populations enough to influence the trends significantly. There is a possibility, however,—that on the smaller *Amelanchier* supporting, of necessity, a lighter infestation

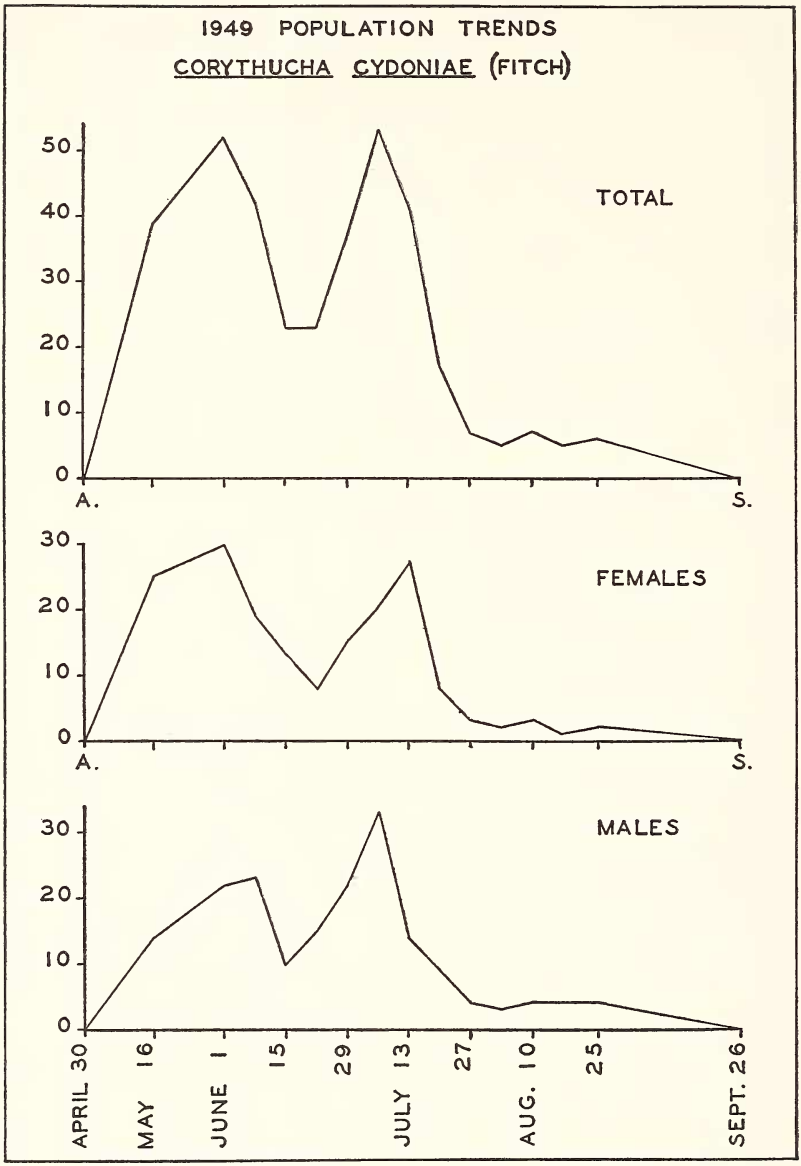
than the *Prunus,* 1949 collections may, in a small way, partly account for the low numbers of overwintering adults taken in the spring of 1950 (see below).

During the 1949 season, temperature, humidity, and light readings were taken on the wood road on each collecting visit. Since it was impossible to go at precisely the same hour each week, and because of rapid and local fluctuations in all three, it was concluded such data had no useful significance. The insect populations responded to the broader climatic trends that were reflected by the leaf development of the host plants in spring and the gradual cessation of plant growth in the fall.

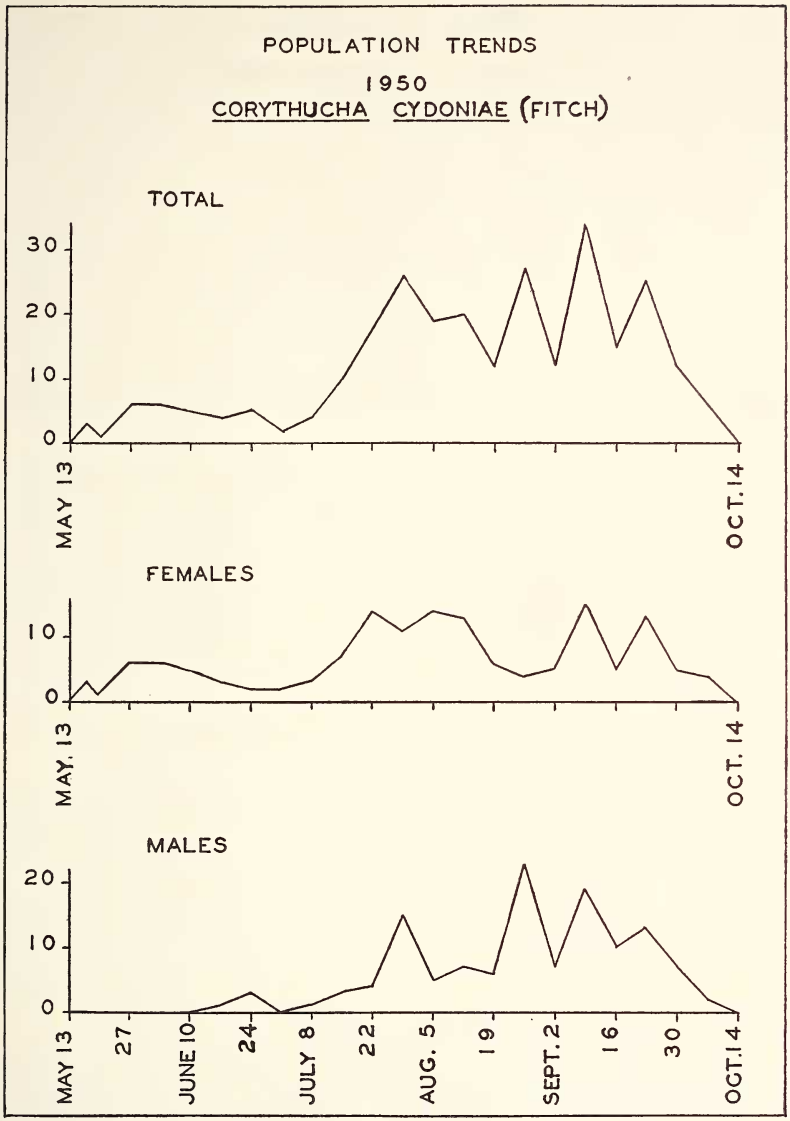
Reference to Graphs 1 and 2 will reveal interesting differences in the population trends for *C. cydoniae* (Fitch) during the 1949 and 1950 seasons. In the spring of 1949 there was a large population of overwintering adults. Many of them were feeding by mid-May and by June 1 the peak was reached. The population then declined rather rapidly and reached its low point between June 15 and 22. By that time teneral adults were appearing and the new generation reached its peak of abundance about July 6. Maturation of this generation took about five weeks, since eggs were first found on May 16 and teneral adults appeared by June 22. The sudden drop in the population by late July suggests some dispersal to other plants and also, perhaps, early hibernation of adults after a short feeding period. By late August very few could be found.

The curve for 1950 is very different. Apparently only a relatively small number of adults survived hibernation. This is probably chiefly the result of a ground fire that spread through the underbrush of the area during the period of dormancy. Much of the surface litter was burned, and many tingids were undoubtedly destroyed. The irregularities of the late summer curve reflect primarily the element of chance in the collection method and in small part the vagaries of New England weather and its influence on insect activity.

In both 1949 and 1950 it will be clearly seen that the hibernating female population is greater than that of males and that the females emerge earlier. The 1949 brood produced somewhat more males than females and they matured about a week sooner. Irregularities in the 1950 curve obscure these relationships. In 1949 a total of 181 males and 178 females were collected. In 1950 the totals were 126 males and 147 females. The males for both seasons


1949 POPULATION TRENDS
CORYTHUCHA CYDONIAE (FITCH)
TOTAL
FEMALES
MALES
50
40
30
20
10
0
A.
S.
APRIL 30
MAY 16
JUNE 1
15
29
JULY 13
27
AUG. 10
25
SEPT. 26

Graph 1


POPULATION TRENDS
1950
CORYTHUCHA CYDONIAE (FITCH)
TOTAL
30
20
10
0
MAY 13
OCT. 14
FEMALES
10
0
MAY. 13
OCT. 14
MALES
20
10
0
MAY 13
27
JUNE 10
24
JULY 8
22
AUG. 5
19
SEPT. 2
16
30
OCT. 14

Graph 2

totaled 307 and the females 325, which gives a sex ratio only slightly in favor of the females.

The graphs all show that this species completes only one full generation in this area. This is strikingly demonstrated in the 1949 figures particularly. Time required for complete maturation from egg to adult can only be roughly estimated. Eggs were found abundant on May 16, 1949, and teneral adults first noted on June 22 after a period of thirty-seven days. In the following year eggs were not found until May 27 and teneral adults appeared on July 15. The cooler spring of 1950 delayed development and the interval was forty-eight days. Depending on the weather, therefore, completion of the life cycle in spring takes five to seven weeks.

There are two other items of interest in respect to this species. Parshley (1917b) found a specimen in ocean drift along with a few other tingids and various Heteroptera.

Sailer (1945) described the effects of being bitten by an individual of this species. Many heteropterous insects, as he suggests, will use the rostrum to probe almost any surface on which they alight. In such cases the bite is purely accidental. In the instance reported, the lace bug reddened a square inch of the author's forearm by inserting the stylets six times. An itching sensation resulted, but all irritation and evidence of the bites was gone by the next morning.

Corythucha heidemanni Drake, in Gibson, 1918, p. 87.

Corythucha borealis Parshley, in Gibson, 1918, p. 92.[5]

This a rather variable species and so much resembles the equally variable *C. juglandis* (Fitch) that the two are easily confused when employing the usual criteria. They differ in their food habits. *C. heidemanni* is almost invariably found on *Alnus* (Corylaceae) in northern New England, while *C. juglandis* is usually associated with species of *Juglans* wherever plants of that genus occur in this region. Males of the two species are easily separated by differences in their external genitalia. In *C. heidemanni* (Fig. 5H), the ninth segment tapers decidedly more towards the base of the claspers and at that point the segment is noticeably narrower than the same part of *C. juglandis* (Fig. 6A). Another difference

[5] According to Blatchley (1926), this is a synonym. However, the small size given by Parshley for his species is beyond the limits of variation of *C. heidemanni* in my experience. The entire situation should be re-examined.

seen in the two figures is the relative bluntness of the clasper extremities of *C. heidemanni* when compared with the sharp-tipped claspers of *C. juglandis*. These differences are constant in the specimens examined and provide a more certain means of identifying the two species. The size of *C. heidemanni* is about 3.0 to 3.7 mm. long and about 1.7 to 2.0 mm. wide.

Corythucha heidemanni Drake is known from Ottawa, Canada, New York, and New England. Most of the New England records are for the northern states with only Chester, Massachusetts (Parshley), and Litchfield, Connecticut (New Haven Experiment Station), represented in the southern parts of this region. The species has been collected in Maine at Boothbay and Bar Harbor (*fide* Sailer); Waldoboro (F. B. Burrill); Edmonds, Whiting, Baring, and Crawford (A. G. Humes); Jackman, Greeleys Landing, Ouellette, Roque Bluffs, at the Forestry Camp on Route 16, and Swans Island (Bailey). The specimens collected by Mr. Burrill and Dr. Humes are in my collection. The only New Hampshire records seem to be those in my 1949 collection. The first of these was on Route 3, north of Bucks Pond. The second was by the Third Connecticut Lake, and the other was in Errol. Parshley (1920b) recorded this species from Woodford, Vermont, and there are specimens in my collection from Island Pond, Vermont. A final record of interest is St. Andrews, New Brunswick, where Dr. Humes found the species in July of 1950. This is the first record of their occurrence in that province.

With very few exceptions, the host plant is given as *Alnus*. Drake (1919b) said that the species infests birch in the Cranberry Lake, New York area and later (1928a) he mentions *Ulmus americana* L. and *Ulmus fulva* Michx. (now *U. rubra* Muhl.) as hosts. My collections have, with one interesting exception, always been from *Alnus*. The exceptional case was a good series from *Sorbus* on Route 3, north of Bucks Pond, New Hampshire. Since the series includes nymphs, it is evident that *C. heidemanni* can breed on this plant also.

In central New England *C. pergandei* Heidemann is the species most commonly found on *Alnus*. The ecological factors that determine the distribution of these two species of *Corythucha* on the same host should be studied. At this time the northern limits of *C. pergandei* and the southern limits of *C. heidemanni* can only be roughly approximated. There is a need for more intensive collecting in Maine, New Hampshire, and Vermont to establish the facts and to supply more ecological data.

The extremes of seasonal activity from the records at hand are from June 3 to September 9 in Maine. Early nymphs are present in a collection made on July 13 in Crawford, Maine, by Dr. A. G. Humes, and late nymphs were found on September 8 at Roque Bluffs, Maine. There is no other information concerning this species.

Corythucha hewitti Drake, 1919b, p. 159.

The New Haven Experiment Station collection contains a single specimen taken on July 11, 1939 in Oxford, Connecticut by Mr. H. L. Johnson. This was identified as *C. hewitti* Drake by Professor Drake himself in 1947. However, it looks to me more like *C. pergandei* Heidemann than like two specimens of *C. hewitti* which I obtained from Professor Parshley and another which Professor Drake apparently sent to New Haven from his own collection. Since Hurd (1946) lists Manitoba, British Columbia, Iowa, Colorado, and Pennsylvania for records of this species, it possibly occurs further east. Nevertheless, until more conclusive evidence is at hand, I shall consider this record very uncertain.

The species is said to be 2.78 mm. long and 1.5 mm. wide (Drake, 1919b). It is allied to both *C. coryli* Osborn and Drake and *C. bellula* Gibson. The specimens on which the description was based were found on *Corylus americana* Walt.

Corythucha juglandis (Fitch), 1857.

Tingis juglandis Fitch, 1857, p. 148.
Corythucha contracta Osborn and Drake, 1916a, p. 230.
Corythucha parshleyi Gibson, 1918, p. 83.

The synonymy (Drake, 1921, and by direct communication) attests the confusing variability of *C. juglandis* (Fitch). The difficulties of identification are also increased by the unusually varied food habits of this species. In the discussion under *C. heidemanni* O. and D., the resemblances and differences between the two species were pointed out. The hood areolae of *C. juglandis* are somewhat larger and the nervures of the crest of the hood are dark brown. The males are further distinguished by their sharp pointed claspers (Fig. 6A). They vary in size from 3.3 to 4.0 mm. long and from 2.0 to 2.3 mm. wide.

This species occurs throughout central and eastern North America (Hurd, 1946). Records for New England are so numerous that it is apparent the species may be found wherever suitable food plants grow. Professor Parshley (1917c) has published enough

records to suggest a rather general distribution in the northeast. However, no published Vermont records could be located. The collection of the Boston Society of Natural History contained Vermont material, and on my 1949 trip the species was taken in five additional localities. On the trip, *C. juglandis* was collected from six different genera of plants and in thirteen different places. Besides the five Vermont towns, collections were made in one New Hampshire community, five Maine localities, and at two places in New Brunswick. These are also the first records for that Canadian province (Bailey).

Weiss and Dickerson (1918b) published their observations on the biology of this species under the name *C. parshleyi* Gibson.

Eggs: The eggs are .51 mm. long and .14 mm. wide. They are elongate oval and slightly curved on the long axis. The basal end is rounded and the egg gradually tapers towards the opercular end. There is a slight constriction just below the cap. The operculum is broadly rounded and deep with a nipple-like median projection less than a third of its total length. The attached end of the egg is translucent, but the free end is dark brown or black. The eggs are laid on the lower side of the leaves. Most of them are placed singly or in small groups in the angles between the strongly costate mid-rib and the larger veins that branch from it near the base of the leaf. They stand more or less perpendicular to the leaf surface and usually close to the veins. The leaf pubescence of the usual hosts partly obscures the eggs. In New Jersey egg laying starts in late May. Eggs in the process of hatching were found on August 30 in Woodford, Vermont. The period of oviposition, therefore, is apparently rather extended.

Nymphs: The authors describe five nymphal stages in detail. They are similar to those of other species of *Corythucha*. In New Jersey they noted second stage nymphs by the third week of June and even a few fifth instars were then present. The first brood matured early in July and by the last week of July first instar nymphs were again observed. Because of the extended periods of oviposition, nymphs of all stages may occasionally be found together during the summer. By late August, second brood adults appear. Consequently, nymphal development takes about a month.

The nymphs remain in groups feeding on the lower leaf surface. Their activity results in the usual discoloration of the upper surface and, in heavy infestations, may cause some leaves to turn yellow and fall prematurely.

Adults: Two annual broods are reported for the species in New Jersey. First brood adults appear in early July and by late August and early September the second generation is mature. Therefore, an estimated six weeks is suggested as the time required for completion of the life cycle.

With the exception of a single individual found in ocean drift (Myers, 1926), this species is usually taken on its food plants. Species in the genus *Juglans* seem to be preferred, but at times other plants support *C. juglandis* in considerable numbers. At least three species of *Juglans* (*J. cinerea* L., *J. nigra* L. and *J. sieboldiana* Maxim.) may be infested. The pecan (*Carya illinoensis* (Wang.) K. Koch) is a related host plant. Weiss and Dickerson (1918b) indicate that *Amelanchier* is mentioned in error by Gibson (1918). In New England, *J. cinerea* L., the butternut, is the usual host. Out of seventeen collections made in northern New England in the late summer of 1949, eight were from butternut. Another host reported in the literature is *Tilia,* and two of my collections were from the linden. In both cases *C. juglandis* (Fitch) and *Gargaphia tiliae* (Walsh) were found on the same trees. Genera not previously reported as hosts are *Rubus, Sorbus,* and *Salix.* Three collections were made from *Sorbus* and one of them includes first instar nymphs and eggs in a leaf, which proves that this plant may serve as a true host. The collection from *Rubus* is interesting. A roadside butternut in Speerville, New Brunswick, was heavily infested, and blackberry bushes under the tree had numerous lace bugs on them. The bugs were evidently feeding on the blackberry leaves. Elsewhere a very few were taken from a *Salix,* but they may well have been accidentals. Two collections were made on elms, one in Maine and one in New Brunswick. Nine or more were found on the elm in New Brunswick, which suggests the plant is a satisfactory food source. This species was common on elms in Ontario during 1933 (Twinn, 1934). On another occasion, one or two were found on *Ostrya,* but the tree grew beside a butternut and the few lace bugs were almost certainly strays.

Corythucha marmorata (Uhler), 1878.

Tingis marmorata Uhler, 1878, p. 415.
Corythucha marmorata var. *informis* Parshley, 1919c, p. 20.

This species has occasionally been confused with *C. decens* Stål, but such references are in error since the latter does not occur in North America (Drake, 1926). *C. marmorata* (Uhler) is easily

separated from other New England species by the whitish opaque ground color of the membranous structures and by their mottled appearance. The marmorate pattern is rather variable and is usually more intense in males. In all features this common and wide-ranging species shows considerable variation, which has led to the naming of such extreme forms as the variety *informis* of Parshley. Typical *C. marmorata* has the hood nearly twice as high as the median carina. The hood is large and strongly constricted. Its sides are often nearly vertical and so little rounded that the hood appears to be somewhat laterally compressed. The median carina itself is highly arched and rather short. The lateral carinae are mere tabs at the anterior angles of the triangular process. Commonly there are numerous long spines on the nervures of the hood, paranota, and discoidal elevations. The long, slender tips of the claspers of the males (Figs. 6B and C) easily distinguish them from other species considered. As might be expected, there is very little difference in the claspers of typical *C. marmorata* (Fig. 6B) and those of the variety *informis* (Fig. 6C). *C. marmorata* var. *informis* has very short hemielytra with relatively larger discoidal elevations than in *C. marmorata* itself. The discoidal area extends behind the middle of the hemielytron in the variety also. In my New Brunswick collections considerable variation in hemielytral length was evident, but in all specimens the hemielytra were noticeably shorter than in any individuals of *C. marmorata* at hand. In the variety *informis,* the hemielytra togther are a little broader than long. *C. marmorata* is 3.0 to 3.4 mm. long and 1.7 to 2.0 mm. wide. The variety *informis* is 2.7 to 3.0 mm. long and 1.7 to 1.9 mm. wide.

According to Hurd (1946), the species is known throughout the entire United States. There are also Canadian records (Parshley, 1919c and 1923a). The variety *informis* occurs in British Columbia, Nova Scotia, Colorado (Parshley, 1919c) and South Dakota (Parshley, 1922a). There are specimens in my collection from two New Brunswick localities. This form has not yet been reported from New England, however. Records for *C. marmorata* (Uhler) are so numerous that the general occurrence of the species in this region is well established (see Parshley, 1917c and 1923b for a few). This lace bug feeds on a variety of Compositae and is very generally associated with asters, goldenrods, and ragweed. The food habits of the variety are the same as those of *C. marmorata* itself.

Eggs: Felt (1903) described the eggs as ovate and somewhat fusiform. They are about .5 mm. long and .25 mm. in diameter.

He found they were laid on the under side of *Chrysanthemum* leaves along the larger veins. Those I observed in early April were mostly on the upper side of the leaves. This may be a result of lower temperatures at that time of year, since Felt made his study in mid-June. The eggs are inserted under the epidermis until only the conical, yellowish operculum is visible. The exposed tip is truncate and the cap slightly ridged. Weiss and Lott (1924a) found eggs in wild aster leaves. These were also inserted along the larger veins and even in the vein tissues from the lower side. They were arranged in irregular rows more or less parallel to the veins. Usually from 4 to 75 were in a group and in some leaves as many as 150 eggs were counted. As a rule only the cap was exposed, but in a few cases half of the egg protruded from the leaf. The usual brown, varnish-like deposit over the eggs made their detection easy. Even leaves badly injured by nymphal feeding were found to contain eggs. Abbott (1935) reported eggs of this species from oak leaves. His paper reveals an unfamiliarity with the literature on tingids, and, although possible, it seems unlikely that *C. marmorata* would use oak for a host. The eggs were more likely those of *C. arcuata* (Say) that normally lives on oak. Later in the season he (*ibid.*) found eggs in ragweed, which is a natural host plant. In *Ambrosia trifida* L. the eggs are laid much as in the plants already discussed. Barber and Weiss (1922) reproduce Felt's plate which figures the eggs.

Nymphs: Felt (1903) described the five nymphal instars fully and his Pl. 4 gives figures (Figs. 4 and 9) of instars two and four respectively. The plate also shows some of the nymphal spines in great detail. His suggestion that the cycle is nearly completed in twelve days seems unlikely in the light of more exact figures for other species in this genus. There may have been a printing error in the dates given in the paper. Weiss and Lott (1924a) noted the usual colonial habit of the nymphs. They found recently hatched ones feeding close to their empty egg shells. From 6 to 100 nymphs were counted in such groups. Frequently an adult female was near each colony. Abbott (1935) remarked that the egg cap may be torn off completely and cling to the emerging nymph. More often it is simply pushed aside and remains attached to the empty egg shell. Feeding of the developing nymphs results in characteristic lace bug injury to the foliage.

Adults: With a few questionable exceptions (Abbott, 1935), both the species and its variety have always been associated with

plants in the family Compositae. They have often been reported from *Aster, Ambrosia, Chrysanthemum, Helianthus,* and *Solidago* species. In my collection there are specimens from all of these plants and I have found breeding populations on all but *Helianthus.* Another breeding host, apparently not previously recorded, is *Tanacetum.* In eastern Massachusetts feeding adults have been collected from March 29 until September 4. In seasons favorable to activity in early April, probably more than one brood is produced, since eggs were found in leaves of a garden *Chrysanthemum* in late March of 1945 and by April 7 they were numerous.

Thamnophilous species of *Corythucha* generally inhabit only the lower leaf surfaces. *C. marmorata,* however, may be found on either the upper or the lower surface depending, probably, on the intensity of the sunlight and the temperature. Early in the season the lace bugs on the chrysanthemums were mostly on the upper side of the leaves, but specimens collected from goldenrods and asters during mid-summer are usually on the lower surface. As Bueno (1925) points out, they frequently are present on the under side of the basal leaves of roadside goldenrods and, in asters with basal leaf rosettes, that is also their usual center of activity.

C. marmorata has some economic importance, particularly as a pest of chrysanthemums. The feeding damage to garden varieties may be severe and decidedly injurious at times. In all probability other cultivated composites may be liable to infestations. Osborn and Drake (1917a) state that this species has been reported as injurious to greenhouse plants.

This was one of the tingid species Parshley (1917b) found in ocean drift. Since it often feeds on seaside goldenrod, *Solidago sempervirens* L. (Weiss, 1924), which may grow just above the surf line, this is not surprising.

On several occasions on sunny days in early April of 1945, I observed a curious habit of this species. Individuals could often be seen on chrysanthemum leaves or on pebbles beside such plants exposed to full sunlight and teetering backwards and forwards for several minutes at a time without interruption. Usually the insect would remain in one position, but the teetering was sometimes continued when a bug was walking to another place on the leaf. Watching them reminded me of the similar activity of sandpipers.

Adults are known to hibernate. Bueno (1924a) reported one found by Mr. C. A. Frost in dry leaves in October and he later (1945) mentioned finding them under stones on a hillside. Froesch-

ner (1944) says they hibernate in grass clumps and in debris on the ground.

Corythucha mollicula Osborn and Drake, 1916b, p. 12, Fig. 2.

Corythucha salicis Osborn and Drake, 1917a, p. 298.
Corythucha canadensis Parshley, 1919c, p. 18.

The nearly complete absence of marginal spines on the paranota and hemielytra makes *C. mollicula* O. and D. one of the most distinctive species in the northeast. Although the color is rather variable, areolae of the paranota are usually whitish opaque. Nervures of the globose portion of the hood and the hemielytral bars are dull fuscous. The hood is small and, though low, is about twice as high as the median carina. The areolae of the hood are about the same size as the paranotal areolae. The general outline of the male genital segment (Fig. 6D) is sufficiently different from other New England species to aid in the identification. *C. mollicula* varies in size from 2.6 to 3.5 mm. long (Parshley, 1919c) and from 1.2 to 2.1 mm. wide.

This species ranges from southern Canada and the northern United States, south to Missouri (Froeschner, 1944) and Florida (Drake, 1921). New England records are not numerous, but, from my own collections and the records available, it is apparent that the species occurs throughout the area. Because it feeds primarily on shrubby willows, it would attract less attention than some other tingids. Proctor (1946) noted its presence on Mt. Desert Island, Maine. Specimens are known from Orono (*fide* Sailer and Parshley). New records for Maine include Brassua Lake, China, and Houlton (Bailey). There are specimens from Durham in the University of New Hampshire collection. No Vermont material has been seen. Massachusetts localities are most numerous. They include the Middlesex Fells (Osborn and Drake, 1917a), Holliston (Museum of Comparative Zoology), Georgetown, Rowley, and the Stony Brook Reservation in Boston (Bailey). There are specimens from Kingston in the Rhode Island State College collection. Parshley (1923b) published the Thompson, Connecticut, record.

There is very little concerning the biology of *C. mollicula* in the literature. Drake (1921) notes that adults hibernate under leaves and rubbish on the ground. Most of the reported food plants are species of *Salix* and all of my collections have been from willows. However, Drake (1921) states that they breed on willows and poplars (*Populus*) and also notes that the species was collected on cul-

tivated currants (*Ribes*). In collecting this species it commonly happens that the lace bugs let go and drop to the ground the moment the host plant is disturbed. This habit is shared with a few other tingids. In conclusion, it should be pointed out that Gibson (1918) misspelled the specific names by adding an extra syllable. In his paper it is consistently spelled *molliculata*.

Corythucha pallida Osborn and Drake, 1916a, p. 230.

There is a doubtful record for this species from Mt. Desert Island, Maine (Proctor, 1946). This is probably an error or misidentification. Since the island is a fashionable summer resort, there is, of course, the possibility that this species was introduced and has successfully established itself. Hurd (1946) lists the following states for records of this species: Arizona, Ohio, Maryland, Mississippi, Tennessee, and Virginia. Froeschner (1944) mentions two specimens from Missouri. With such a distribution the Maine record is certainly questionable.

Osborn and Drake (1916a) describe the species as 4.1 mm. long and 2 mm. wide. The same authors (1917a) say numerous specimens have been taken on *Tilia americana* L. and on *Morus rubra* L. McAtee (1923) notes that on Plummers Island, Maryland, they have been collected from April 16 until October 2. There seems to be no other information available.

Corythucha pallipes Parshley, in Gibson, 1918, p. 82.

Corythucha cyrta Parshley, in Gibson, 1918, p. 86.
Corythucha betulae Drake, in Gibson, 1918, p. 86.

It is worthwhile to quote Professor Drake's (1922d) explanation for the synonymy noted above. He wrote:

> "The yellow birch tingitid made its appearance under three different names—viz., *pallipes* Parshley, *cyrta* Parshley and *betulae* Drake—in the same paper by Gibson (1918, pp. 69–105) on the study of the Genus *Corythucha* Stål. According to pagination *pallipes* has page-priority and is the valid name for the species. Parshley (1920, pp. 28 and 29) has recently pointed out the fact that *cyrta* and *betulae* are identical. Dr. Parshley has kindly loaned me the type series of *pallipes* and *cyrta* and we are fully convinced that *cyrta* and *betulae* are not only specifically the same, but also synonymous with *pallipes*. Although *cyrta* and *betulae* can be connected up in the type series, Gibson (l.c., p. 86) failed to observe this iden-

tity. Lack of food-plant data and a series showing variability accounts for the original failure to note the kinship of *pallipes* and *cyrta.*''

This is an excellent example of the taxonomic hazards in the genus *Corythucha.*

The degree of variation in size, relative proportions, and color is considerable. The hood may be barely twice to nearly three times as high as the median carina. Usually the posterior part is remarkably large and globose. It is constricted abruptly in front. Nervures of the hood are embrowned and the areolae slightly colored. The hood areolae are two or three times larger than the paranotal areolae. The latter are sub-opaque. The dorsal nervures that are not fuscous are mostly yellowish white. They vary from 3.5 to 4.3 mm. in length and from 2.2 to 2.6 mm. in width. The external male genitalia are shown in Fig. 6E. They help to distinguish *C. pallipes* from other New England species of similar size.

Drake (1922d) reports the distribution as transcontinental in the northern part of the United States and southern Canada. He (1919b and 1922d) mentions specimens from Maine and so does Parshley (1920c). My collections add ten more localities for the state, which indicate a general range there. New Hampshire is also listed by Drake (1922d) and I have seen specimens from Durham in the University of New Hampshire collection and have collected the species in four other towns. The Museum of Comparative Zoology collection has some Vermont material and mine contains specimens from Woodford, Wilmington, and Morgan Center. Drake (1922d) mentions Masschusetts and in my collection the Arnold Arboretum in Forest Hills, Saugus (John T. Woodland), and Hammonds Woods in Brookline (A. E. Feldman) are represented. There seem to be no Rhode Island records. The New Haven Experiment Station collection contains specimens from Colebrook, Connecticut, and Parshley (1923b) gives Stamford as a locality. Adjacent areas not previously recorded are Applegrove, Quebec, and Richmond Center, New Brunswick.

Eggs: All of the biological information about this species is in a paper by Drake (1922d). The eggs are laid, as usual, on the lower surface of the leaves in the axils of the veins. Only the abopercular end of the egg is inserted in the leaf tissue. Commonly the eggs are in small irregular groups of from four to ten. Pubescence along the yellow birch leaf veins helps to conceal the eggs.

In Pl. 5, Fig. c (*ibid.*), the sub-elliptical, slightly curved egg is

shown. They are about .6 mm. long and not fully a third as wide. The free end is a little constricted and covered by a small cap. The eggs are brown to dark brown and the cap is always noticeably lighter and grayish. Incubation is completed in about ten days.

Nymphs: Drake (1922d) describes the five nymphal stages in detail and they are shown in his Pl. 5, Figs. d to h. The first instar lasts four to six days. The second takes five to ten days. The third requires four to eight days. The fourth lasts five to twelve days. The fifth instar is completed in eight to fifteen days. Nymphal development takes a minimum of 26 days and a maximum of about 51 days. Most nymphs feed in groups on the under side of the leaves. During the later stages there is some tendency to disperse.

Adults: Adults have been collected in New England from mid-July until September 10. They seem to prefer young yellow birch trees (*Betula lutea* Michx.), but will feed on mature plants and on the species noted below. Drake (1922d) reports them from the European *Betula alba* L., but this is probably an error for the native white birch, *B. papyrifera* Marsh. on which I have collected them in Quebec, New Hampshire, and Maine. He considers *Ostrya virginiana* (Mill.) K. Koch a host of secondary importance and found them common on *Fagus grandifolia* Ehrh. *Pyrus americana* (Marsh.) DC. is also listed. In my collection there are eggs, nymphs, and adults from this plant. Drake also found small numbers of this species breeding on *Acer spicatum* Lam., *Acer saccharum* Marsh., *Acer saccharinum* L., and *Acer pensylvanicum* L. *Salix sieboldiana* is mentioned as an introduced host. This may be *S. Sieboldii* Koch which is now *S. elegantissima* Koch. Drake (1919b) uses *Betula lenta* L. apparently in error for *B. lutea* Michx. *Cornus* and *Alnus* records (*fide* Sailer) are very likely accidental.

In the Adirondacks Drake observed two generations a year. The late nymphs mentioned above suggest that this is a distinct possibility in New England also. Adults are said to hibernate among fallen leaves on the ground. Parshley (in Gibson, 1918) reported the species from *Sphagnum,* probably a chance association.

Two predaceous insects were observed feeding on both nymphs and adults. These were *Anthocoris borealis* Dallas and larvae of a species of *Chrysopa* (Drake, 1922d). Drake also saw occasional adults parasitized by small red mites of the genus *Trombidium.* The mites were usually attached to the ventral side of the abdomen. On some specimens I collected in Maine were mites which have not been identified. There is a figure of the adult in Drake's plate (1922d).

Corythucha pergandei Heidemann, 1906, p. 10, Figs. 2 and 3.

This small species has a distinctive appearance and is unlikely to be mistaken for other New England species, with two possible exceptions. In size and color it superficially resembles *C. arcuata* (Say). Specimens of *C. arcuata,* however, are usually somewhat longer and the hood of this species is only slightly higher that the median carina, which is much higher than that of *C. pergandei. C. ulmi* O. and D. is also somewhat similar, but is again slightly larger. The hood of *C. ulmi* is less spherical and somewhat more flattened. Areolae of the hood and hemielytra are plainly shagreened. In *C. pergandei* the hood is barely twice as high as the median carina. It is well-rounded behind and nearly spherical. Both hood and carina are low and small. The small size of the hood distinguishes this species from our other New England species of comparable size. The hood areolae are noticeably larger than the paranotal areolae. Nervures of the hood and of the anterior paranotal lobes are deep brown. Usually both the basal and apical hemielytral bands are prominent, though the latter may not be as fully developed in some individuals. *C. ulmi* never has an apical band even faintly evident. All markings are brown and the other nervures are yellowish. *Alnus* is the preferred host of both *C. pergandei* and *C. heidemanni* Drake. The much larger size and large hood of *C. heidemanni* make confusion of the two unlikely. The external male genitalia of *C. pergandei* are shown in Fig. 6F. The small size of the whole and the relatively broad bases and short tapered tips of the claspers are also distinguishing features. *C. pergandei* is from 2.8 to 3.2 mm. long and from 1.6 to 1.8 mm. wide.

Hurd (1946) gives the range of this species as "most of the United States". Parshley (1914, 1917c, and 1923a) has published a few records for Maine, New Hampshire, Massachusetts, Connecticut, and Nova Scotia. In addition to his records, my collection contains specimens from Clifton, Maine; Lee and Hamstead, New Hampshire; Sunderland, Winooski and Highgate Center, Vermont. My material from Massachusetts comes from six previously unlisted localities. Bueno (1924a) reported the species from Framingham, and the Museum of Comparative Zoology has representatives collected by Mr. N. Banks in Holliston. Specimens from Mt. Toby and from Amherst are in the University of Massachusetts collection. It is therefore apparent that *C. pergandei* is of common occurence in this state. There seems to be no material from Rhode Island.

Parshley (see above and 1923b) gives several Connecticut records and in the New Haven Experiment Station collection Oxford, North Haven, Greenwich, and Durham are also represented.

Eggs: In his paper describing this species, Heidemann (1906) mentioned finding eggs on the underside of black alder leaves, where they were completely hidden by the pubescence in the axils of the mid-rib and its main branches. Weiss and Dickerson (1918a) state that oviposition begins in New Jersey in late May or early June. They noted one to five eggs in each vein axil. Most are at right angles to the leaf surface. They found eggs on birch. The egg is 0.5 mm. long and only 0.11 mm. in diameter. The shape is elliptical and the broadest portion is one-fourth of its length from the basal end. The base is obtusely rounded. From side view one surface is slightly concave. The free end is only half as wide as the greatest diameter of the egg. Just below the conical cap there is a constriction. The apical half of the egg is brown and the lower part sub-translucent.

Nymphs: Heidemann (1906) describes some nymphal features and figures two stages (Fig. 3). Weiss and Dickerson (1918a) describe the five instars in detail. As usual, the young nymphs feed in groups on the under side of the host plant leaves. The discoloration of the upper leaf surface that results is more noticeable on birch than on alder foliage. The extended period of oviposition makes it possible to find all stages of nymphs feeding together. The later stages are more active than the younger nymphs. This is probably because they sooner exhaust the food supply in the leaf tissue.

Adults: In addition to alder, Heidemann (1906) notes specimens labeled as found on elm, hazel, and crab-apple. Most of the published records are *Alnus* and include such species as the European white alder, *A. incana* (L.) Moench (Drake, 1928a) and the European black alder, *A. glutinosa* (L.) Gaertn. (Weiss and Dickerson, 1918a). Drake (1928a) also lists *Alnus rugosa* (Du Roi) Spreng. and says the species is rarely taken on *Prunus americana* Marsh.

Weiss and Dickerson (1918a) name three species of birch, *Betula nigra* L., *B. lutea* Michx., and *B. populifolia* Marsh. I have taken nymphs and adults on the first of these. McAtee (1923) adds willow and *Celtis crassifolia* (now *C. occidentalis* L.) to the list. My local collections have always been from *Alnus,* except for one from *B. nigra* L. in the Arnold Arboretum and one from *Ulmus* growing by a stream along with infested alders.

Adults hibernate under fallen leaves and in the crevices of the bark (Heidemann, 1906). Mr. C. A . Frost has taken them by sifting in mid-October. Active adults have been collected in eastern Massachusetts from June 3 to October 5. In New Jersey they are said to emerge in late May or early June and feed, with egg laying starting soon after. Feeding of overwintering adults is considerable during the period of oviposition. By mid-July adults of the first brood are mature. Copulation takes place and eggs are laid during late July for a second brood. In late August or early September second brood adults appear. These feed and later hibernate. Five or six weeks are needed to complete the life cycle.

Corythucha pruni Osborn and Drake, 1916a, p. 231.

Corythucha pyriformis Parshley, 1920a, p. 2.

The two cherry tingids are the largest of our New England species of *Corythucha*. *C. pruni* is easily distinguished from *C. associata* O. and D. by its low flat hood which is sub-equal with the median carina in height. The hood of *C. associata* is much more rounded and at least twice as high as the median carina. Furthermore, the male claspers of *C. pruni* have blunt, broadly spatulate tips that differentiate them from other New England species (Fig. 6G). Adults are 4.0 to 4.2 mm. long and about 2.3 mm. wide.

Hurd (1946) gives the eastern United States as the range of this species. Parshley (1920a) based his description of *C. pyriformis* on specimens from Peaks Island, Maine, and Franconia, New Hampshire. In his collection there are specimens from Durham, New Hampshire, and from Lincoln, Massachusetts. My collection contains specimens from four additional Maine localities. These are Medford, Willimantic (near Little Wilson Stream), Clifton, and Newburg. Other New Hampshire stations include Plaistow (Boston Society of Natural History) and West Milan (Bailey). No Vermont records have been published, but I have material from Wilmington and Wenlock. Massachusetts records include Sherborn, Marlboro, and Springfield (*fide* Sailer), Hammonds Woods and Brookline (*fide* Feldman), Canton, Dover, Stony Brook Reservation, Newbury, and West Newbury (Bailey). This is one of the commonest lace bugs in eastern Massachusetts.

Regular weekly collections and observations of this species were made during the spring and summer months of 1949 and 1950. The data were gathered, with few exceptions, from a single tree of *Prunus serotina* Ehrhart, which is the only recorded host of this

species, growing beside a wood road in the Stony Brook Reservation in Hyde Park, Massachusetts. Unless otherwise specified, this is the station of reference for the following biological notes. Each collecting period was limited to five minutes in order to furnish comparable data for the population trends shown graphically below. The vegetation of the area has been described above (see *C. cydoniae* (Fitch)) and the method of collecting explained in detail. There is next to nothing in the literature concerning the habits of *C. pruni* O. and D.

Eggs: In 1949 eggs were first noticed on May 16, when they were already numerous. In 1950 none were seen until May 27. Some were observed as late as June 29 in 1949, which indicates an extended period of oviposition. The female population lays eggs for about six weeks after emerging from hibernation. Mating has been observed occasionally throughout the season. By mid-July teneral adults were frequently seen copulating. These late matings account for occasional nymphs seen late in the season. However, some impregnated females may hibernate without ovipositing.

On May 16 and June 1, 1949, cherry leaves bearing eggs were collected. Analysis of these collections provide the data given below. This species lays its eggs in roughly circular patches on the under side of the leaf blade. The eggs in a single mass are usually compactly placed and only the basal ends are slightly inserted in the leaf tissues. Most of the eggs are perpendicular to the blade, but they may lean in any direction. The exposed portion of an egg is dark brown or nearly black and the attached end is almost transparent. The operculum is low and conical. The eggs may occur singly or, more commonly, in groups of as many as sixty-three. A single leaf may bear as many as nine discrete egg clusters, and a total of over eighty eggs have been counted on one leaf. Study of the data will reveal other interesting relationships. The fact that the eggs are deposited in groups on the blade may be related to the fact that the cherry leaves are relatively smooth. Only the mid-rib is prominently costate and there is little pubescence on the leaf surface. Early in the season incubation of the eggs probably takes three or four weeks as indicated below.

I. Eggs of *Corythucha pruni* O. and D. on *Prunus* leaves at Stony Brook Reservation, May 16, 1949. The eggs were usually in compact clusters on the lower side of the leaf blade.

Leaf 1 with 2 masses of 15 and 39 eggs.
" 2 with 1 mass of 13 eggs.

" 3 with 2 masses of 20 and 12 eggs.
" 4 with 1 mass of 4 eggs.
" 5 with 5 masses of 13, 1, 3, 16 and 1 eggs.
" 6 with 1 mass of 5 eggs.
" 7 with 5 masses of 32, 2, 1, 17 and 2 eggs.
" 8 with 1 mass of 12 eggs.
" 9 with 1 mass of 28 eggs.
" 10 with 2 masses of 6 and 4 eggs.
" 11 with 4 masses of 23, 16, 4 and 9 eggs.
" 12 with 1 mass of 12 eggs.
" 13 with 2 masses of 13 and 12 eggs.
" 14 with 1 mass of 9 eggs.
" 15 with 1 mass of 15 eggs.
" 16 with 2 masses of 12 and 2 eggs.
" 17 with 1 mass of 14 eggs.
" 18 with 2 masses of 4 and 9 eggs.
" 19 with 9 masses of 5, 10, 9, 1, 3, 1, 10, 18 and 16 eggs.

A total number of 44 clusters gave 473 eggs in all, an average of about 11 eggs to a cluster and an average of 25 eggs to a leaf.

II. *Prunus* leaves with eggs taken on June 1, 1949.

Leaf 1 with 1 mass of 25 eggs.
" 2 with 1 mass of 3 eggs.
" 3 with 1 mass of 17 eggs.
" 4 with 2 masses of 63 and 11 eggs.
" 5 with 2 masses of 12 and 7 eggs.
" 6 with 1 mass of 20 eggs.
" 7 with 1 mass of 20 eggs.
" 8 with 2 masses of 6 and 9 eggs.
" 9 with 2 masses of 43 and 1 eggs.
" 10 with 5 masses of 10, 5, 11, 29 and 26 eggs.
" 11 with 1 mass of 14 eggs.
" 12 with 2 masses of 14 and 20 eggs.
" 13 with 1 mass of 14 eggs.
" 14 with 1 mass of 38 eggs.
" 15 with 1 mass of 11 eggs.
" 16 with 2 masses of 9 and 38 eggs.
" 17 with 4 masses of 21, 3, 40 and 4 eggs.
" 18 with 2 masses of 12 and 5 eggs.
" 19 with 3 masses of 3, 32 and 36 eggs.
" 20 with 1 mass of 13 eggs.
" 21 with 2 masses of 7 and 52 eggs.

" 22 with 1 mass of 16 eggs.
" 23 with 1 mass of 3 eggs.
" 24 with 2 masses of 20 and 22 eggs.
" 25 with 2 masses of 20 and 16 eggs.
" 26 with 2 masses of 6 and 13 eggs.
" 27 with 1 mass of 3 eggs.
" 28 with 1 mass of 3 eggs.
" 29 with 1 mass of 18 eggs.
" 30 with 1 mass of 9 eggs.
" 31 with 2 masses of 44 and 3 eggs.
" 32 with 1 mass of 55 eggs.
" 33 with 2 masses of 14 and 20 eggs.

A total number of 55 clusters gave 1289 eggs in all, an average of about 23 eggs to a cluster and an average of about 39 eggs to a leaf.

Nymphs: In 1949 the first nymphs were seen on June 8, and on June 17 in 1950. By late June or early July the nymphal population reaches its peak and teneral adults become abundant soon after (*i.e.,* June 29, 1949, and July 15, 1950). An occasional nymph may be seen after mid-July and one late instar was taken on September 23, 1950. This is probably an exceptionally late record for this species. My field notes suggest that nymphal development probably requires three or four weeks.

Adults: Mr. C. A. Frost and I found adults hibernating amongst leaves and coarse dry grasses in a swale. The locality was Framingham, Massachusetts, and they were collected by sifting. He has taken this species by the same method in October and in early April.

Spring emergence is naturally correlated with rising temperatures and with leaf development of the host plant. Favorable conditions came early in 1949. On April 30 the temperature at 4:00 o'clock p.m. (E.D.S.T.) was about 84° F. Leaves of the cherry were nearly expanded and the flower racemes were in early bud. Eight males and sixteen females were collected and others were seen on the lower sides of leaves to a height of ten feet or more above the ground. However, the spring of 1950 was appreciably cooler, showing a characteristic variation for New England weather. On May 8 the cherry leaves were only half expanded and the first lace bugs were taken on May 13. Four males and seven females were found within the five minute limit set for collecting.

In early spring these emerging adults feed actively as the

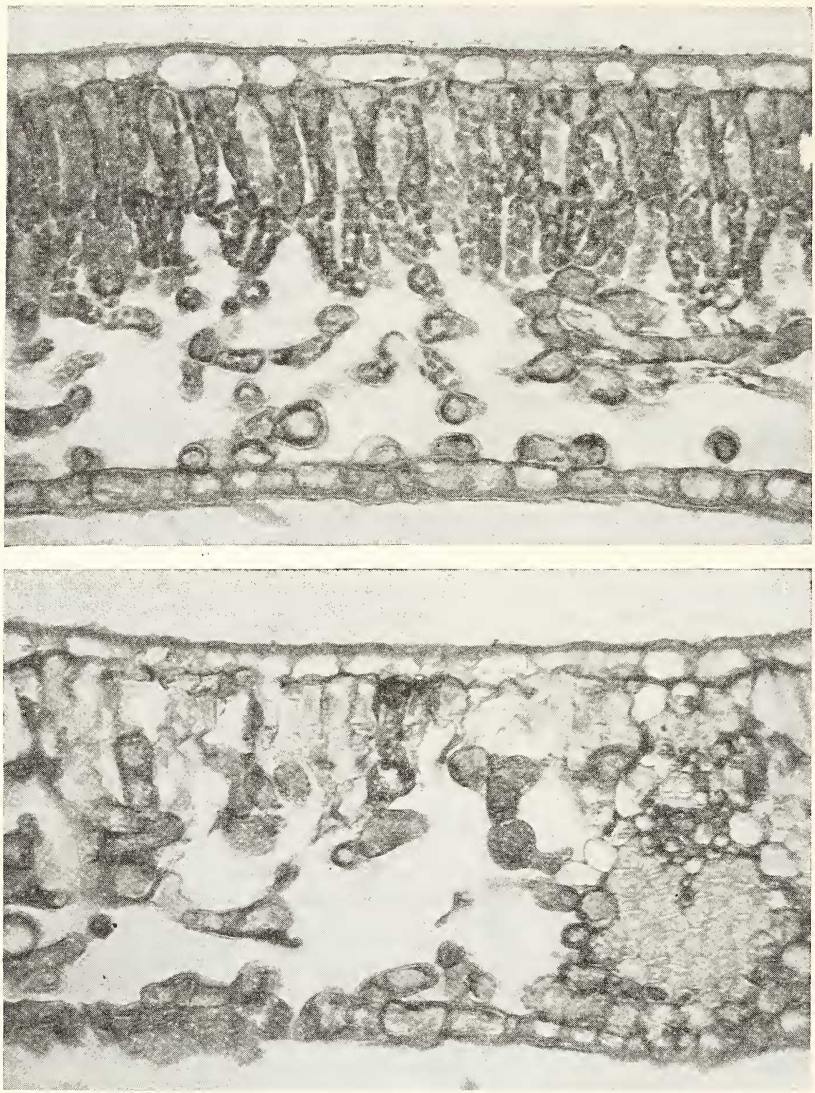


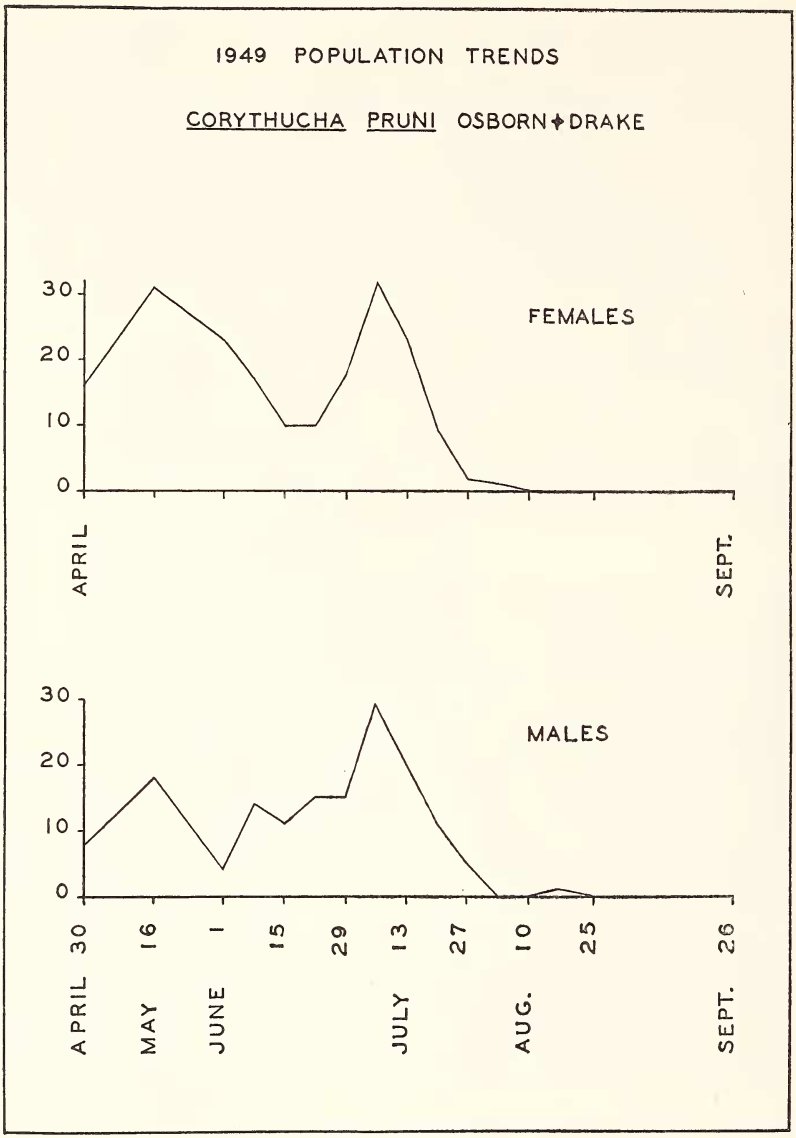
Fig. 4. Leaf sections of *Prunus serotina* Ehrhart. Above, undamaged leaf tissues. Below, chlorenchyma cells emptied by the feeding of *Corythucha pruni* O. and D. Photomicrographs by Mr. Frank White with a 45 × Bausch and Lomb objective and a 4 × Leitz ocular. Actual magnification approximately 375 diameters.

weather permits. Egg laying soon follows, and at this season temperature fluctuations largely regulate the rate of embryonic development. In 1949, twenty-four days elapsed between the first collection of eggs and the first recorded appearance of nymphs. In 1950 the time interval was twenty-two days. Incubation in late May and early June possibly requires three or four weeks. This would leave about the same period for the completion of the nymphal stages and final maturation, since in 1949 there was a 45 day interval between the first collection of eggs and the appearance of teneral adults. In 1950 this period lasted 49 days. Therefore, it probably takes between six and eight weeks for this species to complete its development from the egg stage to the adult.

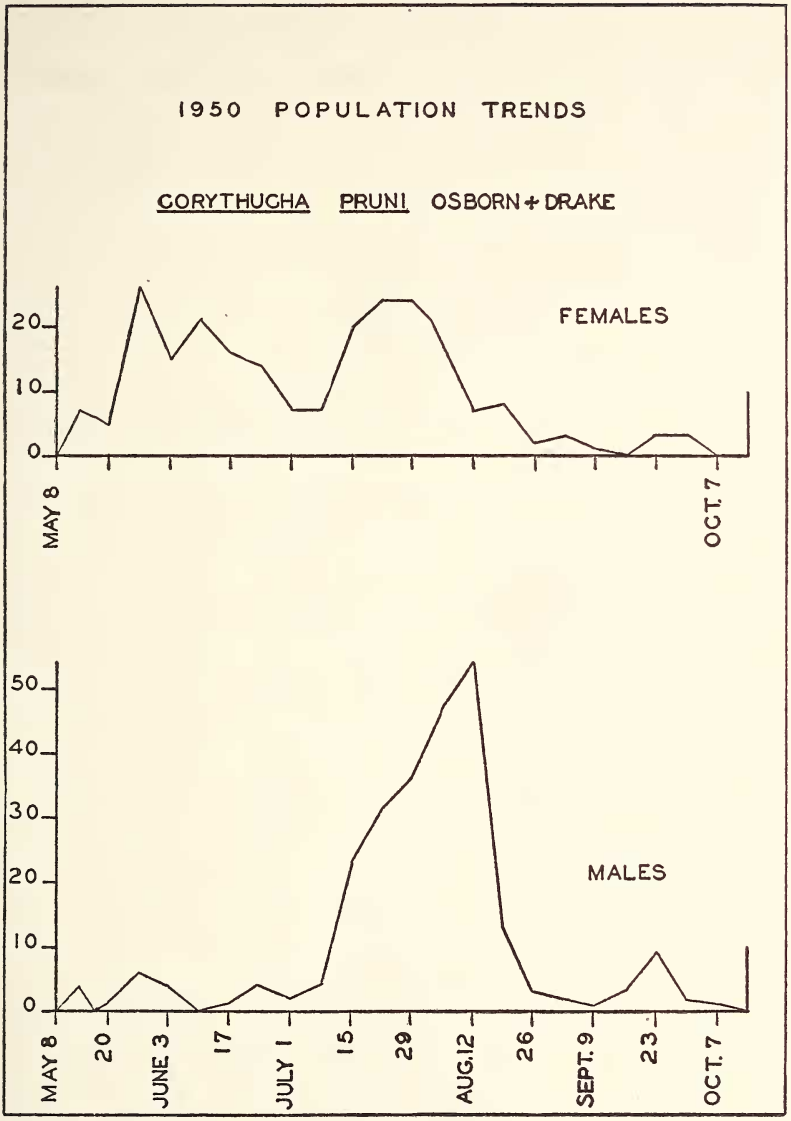
The typical scorched appearance of cherry foliage results from the feeding of numerous nymphs and adults. Practically all of the feeding is done from the lower leaf surface, but on the upper surface the injury is most conspicuous. By mid-July it is often difficult to find a branchlet on a heavily infested tree whose leaves do not show considerable evidence of lace bug feeding. The discoloration is so characteristic that a practiced observer can easily spot infested plants along the roadside as he drives. Preliminary study of damaged cherry leaf sections indicates that the entire contents of both spongy and palisade chlorenchyma cells are withdrawn by the insects. This accounts for the loss of color and is accompanied by some drying of the mesophyll tissues and a shrinkage of cell walls. The upper part of Fig. 4 shows a normal cherry leaf section and the lower photomicrograph shows clearly the results of lace bug feeding. Since the spongy parenchyma of the cherry leaf is thin and scattered, the injury is most obvious in the densely packed palisade cells. Observe in the lower figure that practically every palisade cell is completely empty, whereas in the uninjured section above the chloroplasts are prominent.

C. pruni is very host specific. In the similar study of *C. cydoniae* discussed above, it was noted that collections of the latter were made on an *Amelanchier* growing at the branch tips of the *Prunus*. During the entire 1950 season, however, only five adults of *C. pruni* were found on the *Amelanchier*. They were undoubtedly accidentals that had dropped from the overhanging cherry foliage. *C. pruni* is one of the species that (like *C. mollicula*) habitually lets go and falls from the leaf if the branch is even slightly disturbed.

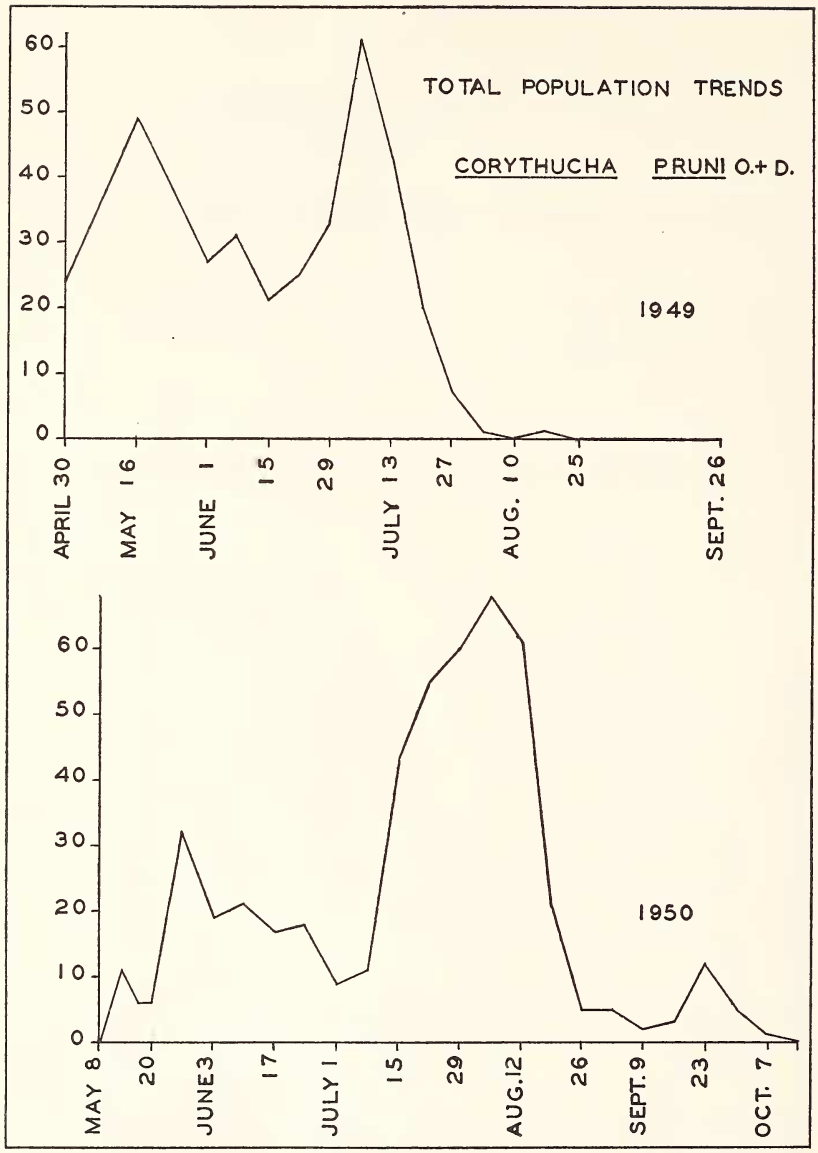
Graphs 3, 4 and 5, depicting adult population trends for this species throughout the 1949 and 1950 seasons, reveal several points


1949 POPULATION TRENDS
CORYTHUCHA PRUNI OSBORN & DRAKE
FEMALES
30
20
10
0
APRIL
SEPT.
MALES
30
20
10
0
APRIL 30
MAY 16
JUNE 1
15
29
JULY 13
27
AUG. 10
25
SEPT. 26

GRAPH 3


1950 POPULATION TRENDS
CORYTHUCHA PRUNI OSBORN + DRAKE
FEMALES
20
10
0
MAY 8
OCT. 7
MALES
50
40
30
20
10
0
MAY 8
20
JUNE 3
17
JULY 1
15
29
AUG. 12
26
SEPT. 9
23
OCT. 7

Graph 4


TOTAL POPULATION TRENDS
CORYTHUCHA PRUNI O.+ D.
1949
60
50
40
30
20
10
0
APRIL 30
MAY 16
JUNE 1
15
29
JULY 13
27
AUG. 10
25
SEPT. 26
1950
60
50
40
30
20
10
0
MAY 8
20
JUNE 3
17
JULY 1
15
29
AUG. 12
26
SEPT. 9
23
OCT. 7

of interest. The first peak of abundance is indicative of the overwintering population. It is noteworthy that in both years the number of surviving females was appreciably greater than the number of males. This was especially marked in 1950. However, the 1950 brood which reached its peak just before mid-August, showed a great preponderance of males. Considering the totals for both seasons, we find 432 females and 402 males, or nearly a 1 : 1 ratio with a slight excess of females. Perhaps most striking is the sharp decline in the population as soon as the new brood reaches its peak. This may be explained in two ways and probably both factors are actually involved. There is perhaps some dispersal to less heavily infested plants in the immediate vicinity and there is also a tendency for this species to hibernate soon after maturation and a short feeding period. These are problems that deserve further study. Both could be investigated by means of marked specimens. Because of the very local nature of many lace bug populations, it seems probable that these insects are relatively sedentary. A final obvious inference from the graphs is the fact that in eastern Massachusetts this species completes only one full generation annually, although a few second brood individuals may possibly occur. The graphs show that the seasonal activity of this species extends over a period of 150 to 160 days.

Corythucha ulmi Osborn and Drake, 1916a.

Corythucha pallida var. *ulmi* Osborn and Drake, 1916a, p. 231.

There are four species of *Corythucha* in New England that lack the apical hemielytral band. It is often absent in *C. arcuata* (Say) and always obsolete in *C. caryae* sp. nov., *C. ciliata* (Say), and *C. ulmi* O. and D. In the three species first named the hood and median carina are nearly equal in height, but in *C. ulmi* the hood is twice as high as the median carina. In color and form *C. pergandei* Heidemann bears a superficial resemblance to *C. ulmi* also, but this species averages somewhat smaller than the latter and the hood of *C. ulmi* is more broadly rounded behind and usually a little flattened on top. *C. pergandei* also has both hemielytral bands well developed. In *C. ulmi* the areolae of the hood are noticeably larger than those of the paranota. Areolae of the hood and of the hemielytra have an unusual shagreened appearance. The male genitalia of *C. ulmi* also have a specific distinctness (Fig. 6H). This species is 3.2 to 3.4 mm. long and about 1.9 mm. wide.

The species is known from New York, Minnesota, South Dakota,

Nebraska, Missouri, Virginia, and Maryland (Parshley, 1922a; McAtee, 1923; Froeschner, 1944; Hurd, 1946). Parshley records Durham, New Hampshire (1922b), and Litchfield, Connecticut (1923b). In the New Haven Experiment Station collection there are specimens from Cornwall, Hickock, and Kent. My collection contains material from Arlington and Larrabee's Point, Vermont, and from Newbury, Massachusetts. The species is certainly not very common in the Boston area. Frequent search for it has so far been unsuccessful.

Concerning the biology of this species, we know only that it feeds on at least three kinds of elms. McAtee (1923) gives *Ulmus americana* L. and *U. fulva* (now *U. rubra* Muhl.) as hosts. My Larrabee's Point, Vermont, collection was from an elm with conspicuously corky ridges on its branches—probably *Ulmus Thomasi* Sarg. Felt (1933) found the species confined to elms growing along fence rows and similar places where good winter cover is available. My specimens are from trees similarly situated in Newbury, and collections date from mid-July until early September. On July 29, 1950, various nymphal stages and many teneral adults were present.

In September of 1947 a few seedling elms were potted up and brought into the laboratory. Two were kept in large lamp chimneys on the window sill at room temperature. About 20 specimens of *C. ulmi* were placed on them. The plants were about a foot tall and held their leaves all winter but made no growth. The tingids remained more or less active. In late March copulation was once observed. However, the insects gradually died and by late spring none were alive. The fact that they survived so long under such artificial conditions is noteworthy.

Specific Characters in the Male Genital Capsule and Claspers of *Corythucha*

The taxonomic significance of the external genitalia of insects is now so widely recognized that such an approach requires no lengthy documentation. In several families of the Heteroptera the use of genital characters is standard practice. Singh-Pruthi (1925) has provided an excellent review of the literature dealing with the morphology of the male genitalia in the Rhynchota. His primary concern was with the broader phylogenetic relationships of the families as indicated by morphological similarities in the aedeagus particularly. In the course of his investigations he

studied five tingids and a European species of *Piesma* as representatives of the Tingoidea. Two of the tingids and the piesmid are described in some detail and the genitalia are figured (Singh-Pruthi, 1925, Pl. 12, Figs. 67–69). Very few figures of tingid genitalia have been published and no others have been as fully interpreted.

Gibson (1918) credits Heidemann with the statement that "male characters were of no use in *Corythucha* and that he could find but little difference in the claspers." Walley (1928) concludes from his study of the male genitalia of Tingidae that they are only of secondary importance to the structures previously employed by taxonomists. He states that in "*Corythucha* many distinct species possess almost identical male genitalia." In other genera he observes that closely related species may be easily separated by genital features.

Walley (*ibid.*) examined slide preparations of nineteen species and one variety in this genus. Since he did not recognize the synonymity of *C. parshleyi* Gibson and *C. juglandis* (Fitch), his statement that distinct species possess almost identical genitalia is somewhat invalidated. Furthermore, the description and figure of each of the four species of *Corythucha* which he studied in detail were based on a single slide preparation. This was his usual procedure. Attempting, as he did, to study representatives of all the North and South American genera of tingids, it is not surprising that he failed to note less obvious differences of definite specific value. His method of preparation itself was such that certain important criteria were likely to be lost in the mounting. Usually he left the genitalia in 10% KOH for about twenty-four hours to clear. In my experience, using about a 5% solution of sodium hypochlorite for only thirty to sixty minutes left the cleared genital capsule so softened that the original shape was often lost or much distorted in mounting. Such drastic treatment must necessarily destroy the normal form and outline of the male genitalia. These features alone are of considerable value on the specific level. Therefore, the use of a caustic clearing agent was avoided entirely or reduced to a minimum time. Furthermore, it is certainly desirable to study more than a single specimen of each species to get some concept of the range of intraspecific variation.

Technique for the Preparation and Mounting of the Male Genitalia

After several months of experimentation with the sodium hypochlorite clearing and acid fuchsin staining, the method was

practically abandoned for a very simple and much more reliable technique. In the process of developing a satisfactory method, twenty or more slides were made for thirteen of the fifteen species of *Corythucha* known to occur in New England. With the single exception of *C. associata* O. and D., for which only four were prepared, material was abundant and six to twelve or more slides of each were prepared by the improved method alone. In some cases (*C. pruni* O. and D., *e.g.*), as many as three dozen preparations were made. Working with this amount of material gave me a degree of familiarity with the species not otherwise obtained. It also showed conclusively that variation in the structure of the male genitalia within a species is remarkably slight. Consequently they provide more reliable taxonomic criteria than many now in use.

The simplified technique finally devised involved first the separation of the male genital capsule, consisting of segment nine and the much reduced tenth segment, from the abdomen. In most cases separation with a spear-pointed needle was very easily effected. Most of the specimens used were in alcohol. In a few instances, specimens on points had to be dismounted and relaxed. Thereafter treatment was identical. Slightly teneral adults were selected when available. These were teneral only in the sense that the pigmentation had not fully developed. This entirely obviated any need for a caustic clearing agent and eliminated any danger of shape distortion. A Coors porcelain spot plate (#000) with twelve depressions proved ideal for processing the specimens. Six specimens were handled on each plate. The six insects were placed in the two outer rows of cells and their genitalia in the adjacent cells of the two inner rows. Each series was lettered and each specimen in the series numbered (A-1 to A-6, *e.g.*). The insects were mounted on points and given pin labels bearing the pertinent serial number for cross reference to the proper microscope slide bearing the genitalia of the specimen.

Immediately after separation, the genital capsules in the cells on the spot plate were covered with distilled water. (In only a few cases was sodium hypochlorite clearing necessary and the time of exposure was reduced to a minimum to prevent over-softening. This meant no more than twenty minutes.) To insure high humidity around them, since the capsules tend to float on the surface, a glass plate was laid over the spot plate. The spot plate itself is a great convenience. Six specimens can be handled at once with a

minimum of space, small quantities of the reagents, and with almost no danger of confusing them.

The next step was to spread the claspers. Sometimes the tissues were relaxed sufficiently to make this possible within an hour. More often the specimens were left in the water overnight and the claspers spread whenever convenient the following day. Mild heat was occasionally used to speed relaxation. Spreading was done under a dissecting microscope with a pair of minuten nadeln mounted in wooden match sticks. The spot plate can be placed on the stage of the microscope for this operation.

After the claspers were properly spread, the specimens were run up through the alcohols into clove oil and left in the clove oil an hour, or until convenient to complete the mounting process. Finally, the clove oil was pipetted off, xylol added, and then the genitalia were transferred to slides and mounted in clarite. The cover glass was supported by a slightly smaller square of plastic that had the center punched out. This was an added precaution against distortion of the genital capsule by pressure from the cover glass. The plastic was just thick enough to prevent any compression. Etched slides were used, and the data recorded on each slide as it was prepared made errors very unlikely. The writing on the etched end was then covered with thin balsam for permanent identification.

METHOD OF PROJECTION FOR DRAWING

Very accurate outlines of the mounted genitalia were obtained by using a right angle projection prism on a Spencer microscope. A 9× wide-angle ocular and a 10× objective were used. For a sufficiently intense light source in a dark room, the Spencer Model 370 lamp proved suitable. With this arrangement the image on the drawing paper was magnified approximately ninety diameters. The figures in Figs. 5 and 6 were all made in this manner, and the scale line on each plate represents one half of a millimeter on the same projection. All figures are shown at approximately one half the magnification of the original drawings (*i.e.*, 50×). Although both camera lucida and photographic methods were tried, the projection method was by far the most accurate and also the easiest to employ.

The genitalia are shown in dorsal aspect. The sternite of the ninth segment extends beyond the tergite and forms the hypandrium. The male claspers or copulatory hooks (called styli by Walley, parameres by Singh-Pruthi, and harpagones by Snod-

grass) are associated with the ninth sternite. See Fig. 1A for a graphic explanation of the terminology.

Features of taxonomic significance include the relative size of the entire genital capsule, the proportional length and width, the general shape of the whole, the outline of the caudal margin of the hypandrium, the shape of the claspers and the acuteness of their tips. Refer to Fig. 1A for an idea of these details.

TAXONOMIC SIGNIFICANCE OF THE GENITALIA

Although Walley (1928) examined the male genitalia of nineteen species of *Corythucha,* he described and figured only four. Two of the four are included in the present study. They are *C. pallipes* Parshley and *C. pruni* O. and D. He considers *C. pallipes* representative of the majority of species he examined in this genus. His Pl. 6, Fig. 7 (Walley, 1928) does not agree too well with Fig 6E of the present paper. We agree even less on *C. pruni* which he shows in Pl. 6, Fig. 9 (*ibid.*), my figure being Fig. 6G. The differences are probably due to his more drastic method of preparation and to the less accurate method of drawing. He made his drawings with only a squared disc in the ocular of a compound microscope to insure correct proportions. Necessarily some of the finer variations would be lost by this method.

Detailed descriptions of the genitalia of each species are omitted since a comparison of the figures is the best way to recognize differences and similarities in specimens to be identified. Some of the important features to be considered have already been pointed out. In the preceding discussion of the species of *Corythucha,* the value of these structures in separating such confusing species as *C. juglandis* (Fitch) and *C. heidemanni* Drake has been emphasized. That they render invaluable aid is unquestionable. The genitalia are not of secondary importance as Walley (1928) contends, but in such homogeneous genera as *Corythucha* are particularly significant and should regularly be used to supplement the criteria now employed. This is especially true since many of the other characteristics used are so variable that they are often misleading. It is therefore desirable to make a comparative study of these structures in all species of *Corythucha* and other tingid genera to more fully validate this point of view which is based on less than 25% of the described species in this genus. Consequently this investigation will be continued as material of other species becomes available.

In conclusion, Mr. A. E. Feldman has made a similar study of the ovipositor in these same New England species of *Corythucha.*

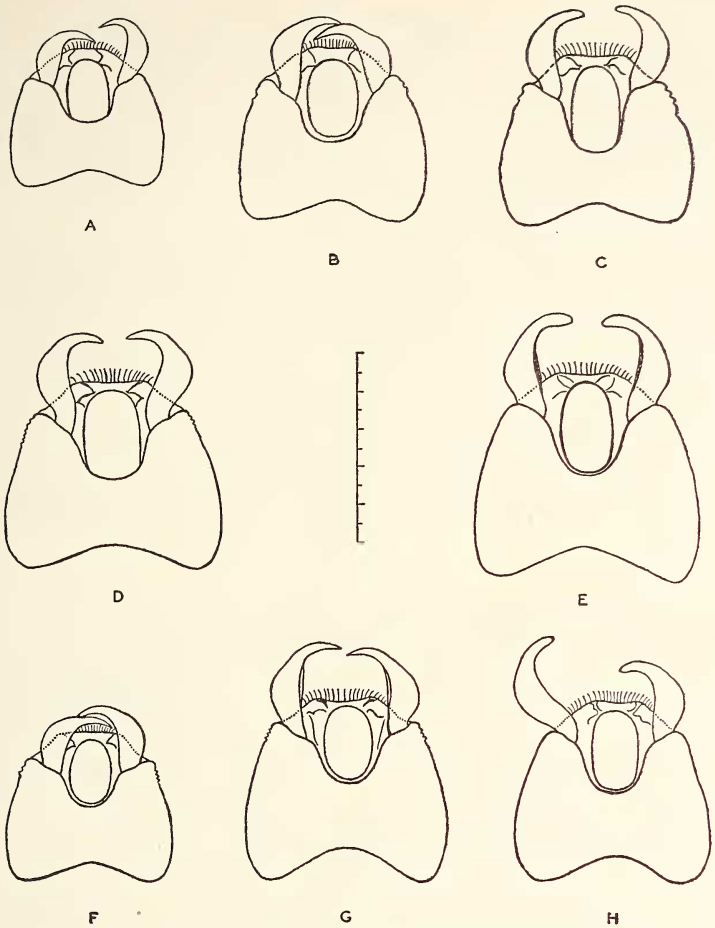


Fig. 5. Genital capsules of *Corythucha,* dorsal aspect. A, *C. arcuata* (Say). B, *C. associata* O. and D. C, *C. bellula* Gibson. D, *C. caryae* sp. nov. E, *C. ciliata* (Say). F, *C. coryli* O. and D. G, *C. cydoniae* (Fitch). H, *C. heidemanni* Drake. Line indicating scale equals 0.5 mm. on the same projection.

His investigations further confirm the usefulness of the genitalia as taxonomic characters in this genus. This work will be submitted for publication in the near future.

Male external genitalia of the New England species of *Cory-*

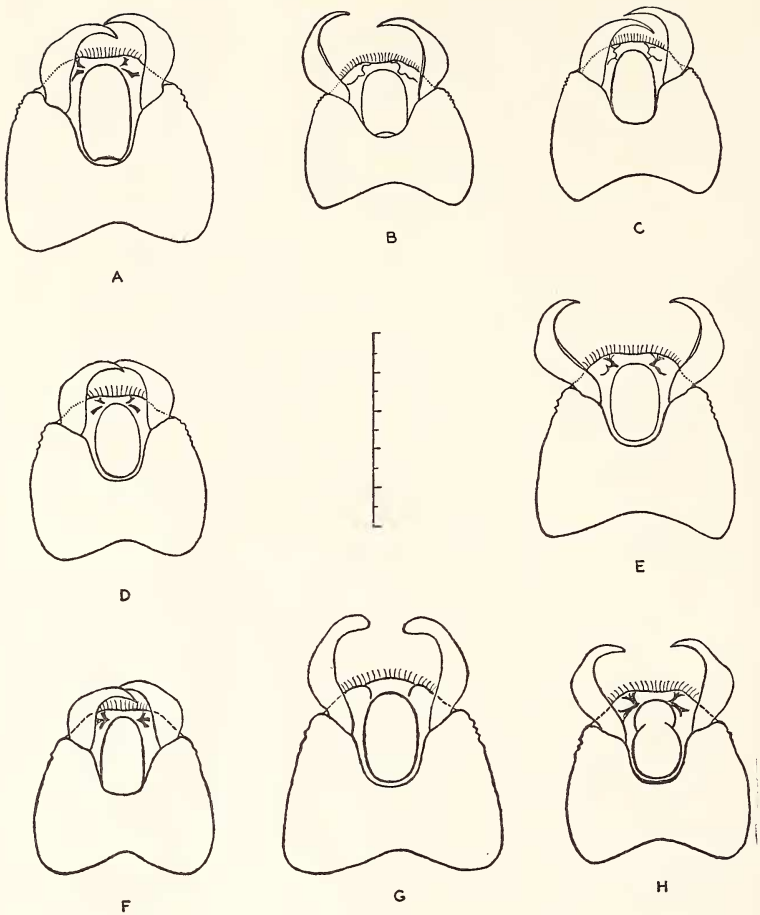


Fig. 6. Genital capsules of *Corythucha,* dorsal aspect. A, *C. juglandis* (Fitch). B, *C. marmorata* (Uhler). C, *C. marmorata* var. *informis* Parshley. D, *C. mollicula* O. and D. E, *C. pallipes* Parshley. F, *C. pergandei* Heidemann. G, *C. pruni* O. and D. H, *C. ulmi* O. and D.

thucha are shown in Figs. 5 and 6, drawn at the same magnification as previously explained. The photographic reproductions are on the same scale, which is indicated by the line on each figure. The line equals one half of a millimeter on the same projection.

Appendix

Check list of New England Tingoidea[6]

Piesmidae

Piesma cinerea (Say), 1832
Piesma cinerea var. *inornata* McAtee, 1919a

Tingidae

Alveotingis grossocerata Osborn and Drake, 1916
Melanorhopala clavata Stål, 1873
(*M. lurida* Stål, *M. uniformis* Stål, *Cantacader henshawi* Ashmead, *M. obscura* Parshley, and *M. reflexa* Blatchley)
Hesperotingis antennata Parshley, 1917a
Hesperotingis antennata var. *borealis* Parshley, 1917a
Hesperotingis illinoiensis Drake, 1918
Physatocheila brevirostris Osborn and Drake, 1916a
Physatocheila plexa (Say), 1832
(*P. parshleyi* O. and D.)
Physatocheila variegata Parshley, 1916b
(*P. plexa* O. and D., 1916a and 1917b)
Leptoypha costata Parshley, 1917a
(*L. distinguenda* Heidemann)
Leptoypha ilicis Drake, 1919a
Leptoypha mutica (Say), 1832
Dictyonota tricornis Schrank var. *americana* Parshley, 1916b
Acalypta lillianis Bueno, 1916
(*A. ovata* O. and D., 1916b; *A. grisea* Heidemann, 1917, *A. modesta* Parshley, 1921)
Acalypta nyctalis Drake, 1928a
Acalypta thomsonii Stål, 1873
(*A. madelinae* Bueno)
Leptopharsa clitoriae (Heidemann), 1911b
(*Leptostyla costofasciata* Drake)
Leptopharsa heidemanni (Osborn and Drake), 1916a
Leptopharsa oblonga (Say), 1825
Galeatus peckhami (Ashmead), 1887
Gargaphia angulata Heidemann, 1899
Gargaphia solani Heidemann, 1914
Gargaphia tiliae (Walsh), 1864

[6] The synonyms are enclosed in parentheses.

Corythaica bellula Bueno, 1917
(*C. floridana* Blatchley)
Stephanitis globulifera (Matsumura), 1905
Stephanitis pyrioides (Scott), 1874
(*S. azaleae* Horváth)
Stephanitis rhododendri Horváth, 1905
(*Leptobyrsa explanata* Heidemann)
Corythucha arcuata (Say), 1832
(*C. mali* Gibson, *C. arcuata* var. *mali* Drake)
Corythucha associata Osborn and Drake, 1916b
(*C. spinulosa* Gibson)
Corythucha bellula Gibson, 1918
Corythucha caryae sp. nov.
Corythucha ciliata (Say), 1832
Corythucha coryli Osborn and Drake, 1917a
Corythucha cydoniae (Fitch), 1861
(*C. arcuata* Comstock, *C. arcuata crataegi* Morrill, *C. crataegi* Osborn and Drake)
Corythucha heidemanni Drake, 1918
(*C. borealis* Parshley)
Corythucha juglandis (Fitch), 1857
(*C. contracta* O. and D., *C. parshleyi* Gibson)
Corythucha marmorata (Uhler), 1878
Corythucha marmorata var. *informis* Parshley, 1919c
Corythucha mollicula Osborn and Drake, 1916b
(*C. salicis* O. and D., *C. canadensis* Parshley)
Corythucha pallipes Parshley, 1918
(*C. cyrta* Parshley, *C. betulae* Drake)
Corythucha pergandei Heidemann, 1906
Corythucha pruni Osborn and Drake, 1916a
Corythucha ulmi Osborn and Drake, 1916a

HOST PLANTS OF NEW ENGLAND TINGOIDEA[7]

Phylum Bryophyta
Class Musci
Climacium americanum L. and
Polytrichum ..... *Acalypta lillianis* Bueno

[7] This list gives only the hosts definitely recorded as food plants. The scientific names of the lace bugs follow their hosts. Starred species are known to breed on the plant indicated. Common names of plants in the literature are disregarded here (though included

Phylum Tracheophyta
Class Angiospermae
Family Gramineae
Panicum ..... **Corythaica bellula* Bueno
Family Cyperaceae
Scirpus atrovirens Willd. ..... *Piesma cinerea* (Say)
Family Salicaceae
Populus species ..... **Corythucha mollicula* O. and D.
Salix elegantissima Koch ..... *Corythucha pallipes* Parshley
Salix species ..... *Corythucha juglandis* (Fitch)
**C. mollicula* O. and D.
C. pergandei Heidemann
Physatocheila variegata Parshley
Family Juglandaceae
Carya illinoensis (Wang.) K. Koch ..... **Corythucha juglandis* (Fitch)
C. ovata (Mill.) K. Koch ..... *Corythucha ciliata* (Say)
C. tomentosa Nutt. ..... *Leptoypha costata* Parshley
Carya species ..... **Corythucha caryae* sp. nov.
Juglans cinerea L. ..... **Corythucha juglandis* (Fitch)
J. nigra L. ..... **Corythucha juglandis* (Fitch)
J. sieboldiana Maxim. ..... **Corythucha juglandis* (Fitch)

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in the earlier discussion) unless the generic reference is assumed to be unmistakable. The plant families follow the order in Gray's Manual and the binomials of native plants are also those of the new edition (Fernald, 1950). Names of cultivated plants agree with those used by L. H. Bailey (1949). Genera and species are arranged alphabetically for convenience.

Family Corylaceae

Alnus glutinosa (L.) Gaertn.	**Corythucha pergandei* Heidemann
A. incana (L.) Moench	*Corythucha bellula* Gibson **Corythucha pergandei* Heidemann
A. glutinosa (Du Roi) Spreng.	**Corythucha pergandei* Heidemann
Alnus species	**Corythucha heidemanni* Drake **C. pergandei* Heidemann *Leptopharsa clitoriae* (Heidemann) *L. heidemanni* (O. and D.)
Betula lutea Michx.	**Corythucha pallipes* Parshley *C. pergandei* Heidemann
B. nigra L.	**Corythucha pergandei* Heidemann
B. papyrifera Marsh.	**Corythucha pallipes* Parshley
B. populifolia Marsh.	*Corythucha pergandei* Heidemann
Corylus americana Walt.	**Corythucha coryli* O. and D.
Corylus species	**Corythucha bellula* Gibson
Ostrya virginiana (Mill.) K. Koch	**Corythucha coryli* O. and D. **C. pallipes* Parshley

Family Fagaceae

Fagus grandifolia Ehrh.	**Corythucha pallipes* Parshley
Quercus alba L.	**Corythucha arcuata* (Say)
Q. macrocarpa Michx.	**Corythucha arcuata* (Say)

Q. Muehlenbergii Engelm. ... **Corythucha arcuata* (Say)
Q. prinoides L. ... **Corythucha arcuata* (Say)
Q. Prinus L. ... **Corythucha arcuata* (Say)
Q. rubra L. ... **Corythucha arcuata* (Say)
Quercus species ... *Corythucha cydoniae* (Fitch)
Piesma cinerea (Say)

Family Ulmaceae
Celtis occidentalis L. ... *Corythucha pergandei* Heidemann
Ulmus americana L. ... **Corythucha ulmi* O. and D.
U. rubra Muhl. ... **Corythucha ulmi* O. and D.
U. Thomasi Sarg. ... **Corythucha ulmi* O. and D.
Ulmus species ... *Corythucha juglandis* (Fitch)
C. pergandei Heidemann

Family Moraceae
Broussonetia papyrifera L. ... *Corythucha ciliata* (Say)

Family Chenopodiaceae
Beta vulgaris L. ... *Piesma cinerea* (Say)
Chenopodium album L. ... **Piesma cinerea* (Say)

Family Amaranthaceae
Amaranthus caudatus L. ... **Piesma cinerea* (Say)
A. hybridus L. ... **Piesma cinerea* (Say)
A. retroflexus L. ... **Piesma cinerea* (Say)

Family Saxifragaceae
Ribes oxycanthoides L. ... *Corythucha bellula* Gibson
Ribes species ... *Corythucha mollicula* O. and D.

Family Platanaceae
Platanus occidentalis L. ... **Corythucha ciliata* (Say)
Piesma cinerea (Say)

Family Rosaceae

Amelanchier species ..... **Corythucha cydoniae* (Fitch)

Chaenomeles species ..... **Corythucha cydoniae* (Fitch)

Crataegus pruinosa (Wendl.) K. Koch ..... *Corythucha bellula* Gibson

C. punctata Jacq. ..... *Corythucha bellula* Gibson

C. succulenta var. *neofluvialis* (Ashe) Palmer ... *Corythucha bellula* Gibson

Crataegus species ..... **Corythucha cydoniae* (Fitch)

Cydonia oblonga Mill. ..... **Corythucha cydoniae* (Fitch)

Malus species ..... *Corythucha cydoniae* (Fitch)

Prunus americana Marsh. ... *Corythucha pergandei* Heidemann

P. serotina Ehrh. ..... **Corythucha associata* O. and D.
**C. pruni* O. and D.

Pyracantha coccinea Roem.... *Corythucha cydoniae* (Fitch)

Pyrus (*Sorbus*) *americana* (Marsh.) D. C. ..... **Corythucha cydoniae* (Fitch)
**C. heidemanni* Drake
**C. pallipes* Parshley
**C. juglandis* (Fitch)

P. (*Sorbus*) *Aucuparia* (L.) Gaertn. ..... **Corythucha cydoniae* (Fitch)

P. communis L. ..... *Corythucha cydoniae* (Fitch)

P. melanocarpa (Michx.) Willd. ..... **Corythucha cydoniae* (Fitch)

Rubus species ..... *Corythucha juglandis* (Fitch)

Family Leguminosae
Amorpha fruticosa L. ..... **Leptopharsa oblonga* (Say)
Amphicarpa bractata (L.) Fern. ..... **Leptopharsa oblonga* (Say)
Baptisia tinctoria (L.) R. Br. ..... **Leptopharsa heidemanni* (O. and D.)
Clitoria mariana L. ..... **Leptopharsa clitoriae* (Heidemann)
Desmodium species ..... *Leptopharsa clitoriae* (Heidemann)
Lespedeza species ..... *Leptopharsa clitoriae* (Heidemann)
Petalostemum species ..... *Leptopharsa oblonga* (Say)
Family Aquifoliaceae
Ilex species ..... *Leptoypha ilicis* Drake
Family Aceraceae
Acer pensylvanicum L. ..... *Corythucha pallipes* Parshley
A. saccharinum L. ..... *Corythucha pallipes* Parshley
A. saccharum Marsh. ..... *Corythucha pallipes* Parshley
A. spicatum Lam. ..... *Corythucha pallipes* Parshley
Family Hippocastanaceae
Aesculus species ..... *Piesma cinerea* (Say)
Family Rhamnaceae
Ceanothus americanus L. ..... **Gargaphia angulata* Heidemann
Family Vitaceae
Vitis species ..... *Piesma cinerea* (Say)
Family Tiliaceae
Tilia species ..... *Corythucha juglandis* (Fitch)
**Gargaphia tiliae* (Walsh)
Family Ericaceae
Chamaëdaphne calyculata

(L.) Moench ..... *Corythucha ciliata* (Say)
Kalmia angustifolia L. .....**Stephanitis rhododendri* Horváth
K. latifolia L. .....**Stephanitis rhododendri* Horváth
Pieris floribunda (Pursh) B. and H. .....**Stephanitis rhododendri* Horváth
Pieris japonica (Thunb.) Don .....**Stephanitis rhododendri* Horváth
**S. globulifera* (Matsumura)
Rhododendron calendulaceum (Michx.) Torr. .....**Stephanitis pyrioides* (Scott)
R. indicum Sweet .....**Stephanitis pyrioides* (Scott)
R. maximum L. .....**Stephanitis rhododendri* Horváth
R. molle Don .....**Stephanitis pyrioides* (Scott)
R. mucronatum Don .....**Stephanitis pyrioides* (Scott)
R. obtusum Planch. var. *amoenum* Rehd. .....**Stephanitis pyrioides* (Scott)
R. ponticum L. .....**Stephanitis pyrioides* (Scott)
R. yedoense Maxim. .....**Stephanitis pyrioides* (Scott)
Rhododendron species ..... *Stephanitis globulifera* (Matsumura)

Family Oleaceae
Chionanthus virginicus L. ...**Leptoypha mutica* (Say)
Forestiera acuminata (Michx.) Poir. ..... *Leptoypha mutica* (Say)
Fraxinus caroliniana Mill. ... *Leptoypha costata* Parshley
Fraxinus species ..... *Corythucha ciliata* (Say)
**Leptoypha costata*

Parshley
L. mutica (Say)

Family Boraginaceae
Lappula species ..... *Leptopharsa clitoriae* (Heidemann)

Family Solanaceae
Lycopersicum esculentum Mill. ..... *Gargaphia solani* Heidemann
Solanum carolinense L. .....**Gargaphia solani* Heidemann
S. elaeagnifolium Cav. .....**Gargaphia solani* Heidemann
S. Melongena L. .....**Gargaphia solani* Heidemann
S. tuberosum L. .....**Gargaphia solani* Heidemann

Family Rubiaceae
Cephalanthus occidentalis L. ..... *Corythucha cydoniae* (Fitch)

Family Compositae
Ambrosia trifida L. .....**Corythucha marmorata* (Uhler)
Aster macrophyllus L. .....**Galeatus peckhami* (Ashmead)
Aster species .....**Corythucha marmorata* (Uhler)
Chrysanthemum morifolium Ramat. .....**Corythucha marmorata* (Uhler)
Eupatorium species .....**Galeatus peckhami* (Ashmead)
Helianthus species ..... *Corythucha marmorata* (Uhler)
Solidago sempervirens L. .....**Corythucha marmorata* (Uhler)
Solidago species .....**Corythucha marmorata* (Uhler)
Melanorhopala clavata Stål

Tanacetum vulgare L. .....**Corythucha marmorata* (Uhler)

CONCLUSIONS AND SUGGESTIONS

Although more of the tingids of the New England area have been the subjects of biological studies than in all the other American territories combined, the number of species in this area about which we still know very little remains unduly large. The species in six of the fourteen genera recorded from this part of the country are so poorly known in most cases that we cannot even assign them to definite host plants. Their eggs and nymphal stages have never been described. Even several relatively common and accessible species of *Corythucha* have been neglected. The most comprehensive studies available have by no means provided full details concerning the life history and habits of even one species. We have much to learn about the longevity of individuals, the local stability of populations, the mobility of species, and the ecological determinants of their distribution.

This paper fully reviews the literature and supplies some additional biological data. However, its most significant feature may be the revelation that the study of tingid biology has only been initiated. Therefore, it seems pertinent to suggest some lines of investigation that should prove both fruitful and interesting.

We shall confine our remarks primarily to the genus *Corythucha*, with the understanding that they apply, with only minor qualifications, to the less known genera. In a few species, general figures for the time of development are available. However, the time necessary for incubation and for the completion of the various nymphal instars should be more accurately determined. There is reason to think that some females may be impregnated in late summer and go into hibernation without ovipositing. This should be investigated since it could be an important factor in the survival of the species.

The ecological factors that influence the local distribution of a species should be carefully studied. The ecology and range of the host plants should also be surveyed and the relationships between the lace bugs and their hosts could then be better evaluated. The vigor of the host plants in relation to the tingid population deserves consideration. By marking large numbers of adults, some knowledge of their tendency to move to other plants or to remain on the same host could be acquired.

It is rather apparent that species in the genus *Corythucha* are

closely related, and it is likely that speciation is still taking place with relative rapidity. Attempts to hybridize some of the species now recognized would be extremely interesting. For this purpose a leaf cage has been designed that, with only minor improvements, should prove satisfactory for such experiments. It has been used enough to demonstrate that it is practical to employ this method of keeping the insects under observation under otherwise natural conditions. Such breeding experiments might also shed some light on the problems of host specificity and phytophagic speciation. Isolation of genetically plastic populations on certain plants has probably contributed significantly to speciation in this genus.

Special attention should also be given to predators and parasites. They may be more important than the sparse data now at hand suggest. Only a few spiders, coccinellid beetles, and predaceous bugs have been directly reported as predators. Mites alone have been occasionally observed parasitizing lace bugs. It is evident that no great effort has been expended on this aspect of tingid ecology.

It is my conviction that further study of the male and female genitalia in *Corythucha* and other genera will confirm the critical usefulness of these structures in taxonomy. The eggs and nymphal instars should also be studied comparatively for specific characters. From the morphological point of view, the Tingidae are especially interesting. These are but a few ideas holding much promise for future investigators.

Selected References

Abbott, Cyril E. 1935. Notes on the Oviposition and Hatching of *Corythucha marmorata* (Uhler). *Brooklyn Entomological Society, Bulletin*, 30: 13.

Amyot, C. J. B. and **J. C. Audinet Serville.** 1843. Histoire Naturelle des Insectes, Hémiptères. Librairie Encyclopédique de Roret, p. 300, Paris.

Ashmead, W. H. 1886. On Two New Hemiptera Heteroptera. *Canadian Entomologist*, 18 (1) : 18–20.

1887. Hemipterological Contributions. Tingitidae. *Sphaerocysta* Stål. *Entomologica Americana*, 3: 156.

Bailey, L. H. 1949. Manual of Cultivated Plants. Macmillan, New York.

Banks, Nathan. 1910. Catalogue of the Nearctic Hemiptera-Heteroptera. American Entomological Society, Philadelphia.

Barber, George W. 1924. Notes on *Piesma cinerea* Say. *Psyche,* 31 (5): 229–232, Figs. 1 and 2.

Barber, H. G. and **H. B. Weiss.** 1922. The Lace Bugs of New Jersey. *New Jersey Department of Agriculture, Circular* 54: 1–24.

Blatchley, W. S. 1926. Heteroptera of Eastern North America. Nature Publishing Company, Indianapolis.

1928a. "Quit-Claim" Specialists vs. the Making of Manuals. *Brooklyn Entomological Society, Bulletin,* 23 (1): 10–18.

1928b. Notes on the Heteroptera of Eastern North America with Descriptions of New Species. *New York Entomological Society, Journal,* 36 (1): 1–23.

Bruner, L. 1891. A List of Insects Affecting Sugar Beets. *Nebraska State Board of Agriculture, Experiment Station Bulletin,* 4 (16): 66–67.

1895. Insect Enemies of the Grape. *Nebraska State Horticultural Report,* pp. 68–162.

Bueno, J. R. de la Torre. 1915. Heteroptera in Beach Drift. *Entomological News,* 26 (6): 278.

1916. A New Tingitid from New York State. *Brooklyn Entomological Society, Bulletin,* 11 (2): 39–40.

1917. A New Species of Tingid from New York. *Brooklyn Entomological Society, Bulletin,* 12 (1): 19–20.

1924a. On a Few Heteroptera from Massachusetts. *Brooklyn Entomological Society, Bulletin,* 19 (2): 48–51.

1924b. A Correction in *Acalypta. Brooklyn Entomological Society, Bulletin,* 19 (3): 93.

1924c. Gaditanus, Being Additional Words on Tingitidae. *Entomological News,* 35 (9): 333–334.

1925. Food plant of *Corythucha marmorata* (Uhler). *Brooklyn Entomological Society, Bulletin,* 20 (4): 179.

1926. Some Remarks, Al Vuelo, on Tingitid Names. *Brooklyn Entomological Society, Bulletin,* 21 (3): 116–117.

1931. *Alveotingis grossocerata. Brooklyn Entomological Society, Bulletin,* 26 (3): 149.

1933. New Records of Heteroptera from Arkansas. *Brooklyn Entomological Society, Bulletin,* 28 (5): 228.

1942. Maternal Solicitude in *Gargaphia iridescens* Champion. *Brooklyn Entomological Society, Bulletin,* 37 (4): 131.

1945. Random Notes on Heteroptera. *Brooklyn Entomological Society, Bulletin,* 40 (3): 68.

1946. On *Hesperotingis antennata* Parshley. *Brooklyn Entomological Society, Bulletin,* 41 (3) : 94–95.

Butler, E. A. 1923. A Biology of the British Hemiptera-Heteroptera. H. F. and G. Witherby, London.

Chittenden, F. H. 1900. A new Tingitid on Bean. *U.S.D.A. Division of Entomology, Bulletin,* 23 (n.s.) : 32–33.

Comstock, J. H. 1879. The Hawthorn *Tingis. Report of the Entomologist of the United States Department of Agriculture,* pp. 221–222.

Cotton, R. T. 1917. The Eggplant Lace-bug in Porto Rico. *Porto Rico Department of Agriculture, Journal,* 1 (3) : 170–173.

Crosby, C. R. and **C. H. Hadley, Jr.** 1915. The Rhododendron Lace-bug, *Leptobyrsa explanata* Heidemann. *Journal of Economic Entomology,* 8 (4) : 409–414.

Curtis, John. 1827. British Entomology. Vol. 7, item number 154, London.

1833. Characters of Some Undescribed genera and species. *Entomological Magazine* 1 : 196.

Dickerson, E. L. 1917. Notes on *Leptobyrsa rhododendri* Horváth. *New York Entomological Society, Journal,* 25 (2) : 105–112, Pl. 8.

Dickerson, E. L. and **H. B. Weiss.** 1916. Notes on *Leptoypha mutica* (Say). *Entomological News,* 27 : 308–310, Pl. 16.

1917. The Azalea Lace-bug, *Stephanitis pyrioides* Scott. *Entomological News,* 28 : 101–105, Pl. 9.

1918. *Corythucha spinulosa* Gibson, a New Lace-bug on Wild Cherry. *Entomological News,* 29 : 121–125, Pl. 7.

Downes, W. 1927. A New Species of *Drakella. Canadian Entomologist,* 59 : 60.

Drake, C. J. 1916. A New Tingid from Tennessee. *Ohio Journal of Science,* 16 (7) : 326–328.

1917. Key to Nearctic Species of *Gargaphia* with the Description of a New Species. *Entomological News,* 28 : 227–228.

1918. Notes on North American Tingidae. *Brooklyn Entomological Society, Bulletin,* 13 (4) : 86–88.

1919a. On Some North American Tingidae. *Ohio Journal of Science,* 19 (7) : 417–421.

1919b. On Some Tingidae New to the Fauna of Canada. *Canadian Entomologist,* 51 (6–7) : 159–160.

1921. Notes on Some American Tingidae with Descriptions of New Species. *Florida Entomologist,* 4 (4) : 49–54.

1922a. On Some North and South American Tingidae. *Florida Entomologist,* 5 (3) : 37–43, 48–50.

1922b. Heteroptera in the Vicinity of Cranberry Lake, Tingidae. *New York State College of Forestry, Syracuse University, Technical Publication* 16, vol. 22 (5) : 64–66.

1922c. Contribution toward the Life History of *Galeatus peckhami* (Ashmead). *New York State College of Forestry, Syracuse University, Technical Publication* 16, 22 (5) : 105–110, Pl. 4.

1922d. The Life History of the Birch Tingitid, *Corythucha pallipes* Parshley. *New York State College of Forestry, Syracuse University, Technical Publication* 16, 22 (5) : 111–116.

1923. Some Tingitidae from Japan. *Ohio Journal of Science,* 23 (2) : 102–106.

1925. Concerning Some Tingitidae from the Gulf States. *Florida Entomologist,* 9 (3) : 36–39.

1926. The North American Tingitidae Described by Stål. *Carnegie Museum, Annals,* 16 (3–4) : 375–380, Pl. 34.

1928a. A List of the Insects of New York. Families Piesmidae and Tingitidae. *Cornell University Agricultural Experiment Station, Memoir* 101: 99–103.

1928b. A Synopsis of the American Species of *Acalypta. Brooklyn Entomological Society, Bulletin,* 23 (1) : 1–9.

1928c. Synonymical Notes on Tingitid Genera with the Descriptions of Two New Species from Haiti. *Biological Society of Washington, Proceedings,* 41: 21–23.

1928d. Four Undescribed Tingitids from United States. *Florida Entomologist,* 12 (1) : 3–5.

1930. Notes on American Tingitidae. *Brooklyn Entomological Society, Bulletin,* 25 (5) : 268–272.

1948. New Species of *Stephanitis* Stål Including a List of Species of the World. *Musée Heude, Notes d'Entomologie Chinoise,* 12 (6) : 45–56.

Drake, C. J. and **M. E. Poor.** 1936. The Genera and Genotypes of the Tingitoidea of the Western Hemisphere. *Iowa State College Journal of Science,* 10 (4) : 381–390.

Felt, E. P. 1903. Injurious Insects. *Corythucha marmorata* (Uhler). *New York State Museum, Bulletin,* 76: 125–129.

1933. Observations on Shade Tree Insects. *Journal of Economic Entomology,* 26 (1) : 49.

Fernald, M. L. 1950. Gray's Manual of Botany (Eighth Edition). American Book Company, Boston.

Fieber, F. X. 1844. Entomologische Monographien. Monographie der Tingideae, 20–111. Johann Ambrosius Barth, Leipzig.

1861. Die Europäischen Hemiptera. Tingididae, 116–132, Carl Gerolds Sohn, Vienna.

Fink, David E. 1915. The Eggplant Lace-bug. *U. S. Department of Agriculture, Bulletin,* 237: 1–7.

Fitch, Asa. 1857. Third Report on the Noxious Insects of New York. Item 193. Butternut Tingis. pp. 148–149. Albany.

1858. Fourth Report on the Noxious and Other Insects of the State of New York. *N. Y. State Agricultural Society, Transactions,* 17: 687–814.

1861. The Quince *Tingis*. *Country Gentleman,* 17 (25): 114.

Froeschner, Richard C. 1944. Contributions to a Synopsis of the Hemiptera of Missouri, Part III. *American Midland Naturalist,* 31 (3): 638–683.

Gibson, A. 1904. Basswood, or Linden Insects. *Entomological Society of Ontario. 34th Annual Report:* 52.

Gibson, E. H. 1918. The Genus *Corythucha* Stål. *American Entomological Society, Transactions,* 44 (775): 69–104.

1919a. The Genera *Corythaica* Stål and *Dolichocysta* Champion. *Biological Society of Washington, Proceedings,* 32: 97–104.

1919b. The Genus *Gargaphia* Stål. *American Entomological Society, Transactions,* 45 (789): 187–201.

Göldi, Emil A. 1886. Beiträge zur Kenntniss der kleinen and kleinsten Gliederthierwelt Brasiliens. *Mittheilungen der Schweizer. Entomologischen Gesellschaft,* 7 (6): 233–241.

Heidemann, Otto. 1899. A New Species of Tingitidae. *Canadian Entomologist,* 31: 301–302.

1906. Account of a New Tingitid. *Entomological Society of Washington, Proceedings,* 8 (1–2): 10–13, figs. 2 and 3.

1908. Two New Species of North American Tingitidae. *Entomological Society of Washington, Proceedings,* 10 (1–2): 103–108, Pl. 4.

1911a. Some Remarks on the Eggs of North American Species of Hemiptera—Heteroptera. *Entomological Society of Washington, Proceedings,* 13 (2): 136–137.

1911b. A New Species of North American Tingitidae. *Entomological Society of Washington, Proceedings,* **13** (3): 180–181, Fig. 4.

1914. A New Species of North American Tingitidae. *Entomological Society of Washington, Proceedings,* **16** (3): 136–137.

1917. Two New Species of Lace-Bugs. *Entomological Society of Washington, Proceedings,* **18** (4): 217–220, pl. 17.

Hickman, Dorothy J. 1921. Illustrations of the Male Hooks in *Nabis. Brooklyn Entomological Society, Bulletin,* **16**: 58–59.

Horváth, Geza. 1905. Tingitidae Novae vel Minus Cognitae e Regione Palaearctica. *Musei Nationalis Hungarici, Annales,* **3**: 567–568.

1906. Synopsis Tingitidarum Regionis Palaearcticae Musei Nationalis Hungarici. Separata ex *Annalibus historico-naturalibus,* **4**: 1–118.

1912. Species Generis Tingitidarum *Stephanitis. Annales Musei Nationalis Hungarici,* **10**: 319–329.

1923. A New Species of *Galeatus* from New Mexico. *Carnegie Museum, Annals,* **15** (1): 108–109.

Hurd, Margaret P. 1945. A Monograph of the Genus *Corythaica* Stål. *Iowa State College Journal of Science,* **20** (1): 79–99, Pl. 1, Figs. 1–5.

1946. Generic Classification of North American Tingoidea. *Iowa State College Journal of Science,* **20** (4): 429–489.

Hussey, Roland F. 1922a. On Some Hemiptera from North Dakota. *University of Michigan Museum of Zoology, Occasional Papers,* **115**: 1–23.

1922b. Hemiptera from Berrien County, Michigan. *University of Michigan Museum of Zoology, Occasional Papers,* **118**: 1–39.

Laporte de Castelnau, F. L. 1832. Essai d'une Classification Systématique de l'Ordre des Hémiptères. *Magasin Zoologique,* 1, Nos. 52-55, Supplement. (*fide* Blatchley).

Leonard, M. D. and **A. S. Mills.** 1931. Observations on the Bean Lace-bug in Porto Rico. *Porto Rico Department of Agriculture, Journal,* **15**: 309–323.

Le Peletier de Saint Fargeau, A. L. M. and **J. G. Audinet-Serville.** 1825–1828. Encyclopédie Méthodique, **10,** Entomologie, Paris. (*fide* Blatchley).

Lethierry, L. and **G. Severin.** 1896. Catalogue Général des Hémiptères. Tome III, Hétèroptères-Tingidae, 1–26. R. Friedländer et Fils, Berlin.

Matsumura, S. 1930. The Illustrated Thousand Insects of Japan. Vol. 1. Rhynchota. Toko-Shoin, Tokyo.

McAtee, W. L. 1912. Note on the Hibernation of *Corythucha* and *Milyas*. *Entomological Society of Washington, Proceedings,* 14: 102.

1917a. Key to the Nearctic Species of *Leptoypha* and *Leptostyla*. *Brooklyn Entomological Society, Bulletin,* 12 (3): 55–64.

1917b. A Few Notes Chiefly on the Names of Nearctic Tingidae. *Brooklyn Entomological Society, Bulletin,* 12 (4): 78–79.

1919a. Key to Nearctic Species of Piesmidae. *Brooklyn Entomological Society, Bulletin,* 14: 80–93, fig.

1919b. Corrections and Additions to an Article on *Leptoypha* and *Leptostyla*. *Brooklyn Entomological Society, Bulletin,* 14 (4–5): 142–144.

1923. Tingitoidea of the Vicinity of Washington, D. C. *Entomological Society of Washington, Proceedings,* 25 (7–8): 143–151.

Monte, Oscar. 1940. Catalogo dos Tingitideos do Brasil. *Arquivos de Zoologia do Estado de São Paulo. Revista do Museu Paulista,* 2 (3): 65–174.

Morrill, Austin W. 1903. Notes on the Immature Stages of Some Tingitids in the Genus *Corythucha*. *Psyche,* 10 (324): 127–134, plate 3.

Myers, J. G. 1926. Heteroptera in Ocean Drift. *Psyche,* 33 (4–5): 110–115.

Olsen, C. E. 1923. Distributional Notes on Hemiptera. *Brooklyn Entomological Society, Bulletin,* 18: 164.

Osborn, H. and **C. J. Drake.** 1916a. The Tingitoidea of Ohio. *Ohio State University Bulletin,* 20 (35): 217–251.

1916b. Some New Species of Nearctic Tingidae. *Ohio Journal of Science,* 17 (1): 9–15.

1917a. Notes on American Tingidae with Descriptions of New Species. *Ohio Journal of Science,* 17 (8): 295–307. fig. 2a.

1917b. Notes on Tingidae. *Psyche,* 24 (5): 155–161.

Osborn, H. and **H. A. Gossard.** 1891. Reports on Injurious Insects. *Iowa Agricultural Experiment Station, Bulletin,* 15: 255–273.

Parshley, H. M. 1914. List of the Hemiptera-Heteroptera of Maine. *Psyche,* 21 (5): 139–149.

1915. Hemiptera-Heteroptera of Maine. Corrections and Additions. *Psyche,* 22: 22–23.

1916a. New and Noteworthy Hemiptera from New England. *Entomological News,* 27 (3): 103–106.

1916b. On Some Tingidae from New England. *Psyche,* 23 (6): 163–168.

1917a. Notes on North American Tingidae. *Psyche,* 24 (1): 13–25.

1917b. Insects in Ocean Drift. *Canadian Entomologist,* 49 (2): 45–48.

1917c. Fauna of New England, 14. List of the Hemiptera-Heteroptera. *Boston Society of Natural History, Occasional Papers,* 7: 1–125.

1919a. Note on the Sexes of the Tingid *Melanorhopala clavata* Stål. *Brooklyn Entomological Society, Bulletin,* 14 (3): 102–103.

1919b. A Morphological Note on the Tingoidea. *Brooklyn Entomological Society, Bulletin,* 14 (3): 109–110.

1919c. On Some Hemiptera from Western Canada. *University of Michigan Museum of Zoology, Occasional Papers,* 71: 1–35.

1919d. Note of Rectification. *Brooklyn Entomological Society, Bulletin,* 14 (4–5): 148.

1920a. Hemiptera from Peaks Island, Maine. *Canadian Entomologist,* 52: 80–87.

1920b. Hemiptera Collected in Western New England. *Psyche,* 27 (6): 139–143.

1920c. Hemipterological Notices I. (Tingidae). *Entomological News,* 31 (10): 271–273.

1921. A Report on some Hemiptera from British Columbia. *British Columbia Entomological Society, Proceedings,* 18: 13–24.

1922a. Report on a Collection of Hemiptera-Heteroptera from South Dakota. *South Dakota State College, Technical Bulletin, Number* 2: 1–22.

1922b. New England Hemiptera-Heteroptera. New Records II. *Canadian Entomologist,* 53: 233–239.

1922c. Tingitidae or Tingidae. *Science,* 56 (1451): 449.

1922d. On the Formation of Family Names like Tingidae. *Science,* 56 (1461): 754–755.

1923a. Records of Nova Scotian Hemiptera-Heteroptera. *Acadian Entomological Society, Proceedings,* 8: 102–108.

1923b. Families Piesmidae and Tingidae in the Hemiptera of Connecticut. *State of Connecticut Geological and Natural History Survey, Bulletin,* 34: 694–707.

1925. A Bibliography of the North American Hemiptera-Heteroptera. Smith College, Northampton, Massachusetts.

Pemberton, C. 1911. The California Christmas-berry Tingis. *Journal of Economic Entomology,* 4: 339–343, Pls. 12–14.

Proctor, William. 1946. Insect Fauna of Mt. Desert (Part 7), pp. 74–75. Wistar Institute of Anatomy and Biology, Philadelphia.

Provancher, l'Abbé L. 1886. Petite Faune Entomologique du Canada. Vol. 3. Les Hémiptères. C. Darveau, Québec.

Reuter, O. M. 1912. Bemerkungen über mein neues Heteropterensystem. *Öfversigt Finska Vetenskaps-Societetens Förhandlingar,* 54 (A, 6): 49.

Robinson, B. L. and **M. L. Fernald.** 1908. Gray's New Manual of Botany (Seventh Edition). American Book Company, New York.

Sailer, R. I. 1945. The Bite of a Lacebug. *Kansas Entomological Society, Journal,* 18 (2): 81.

Say, Thomas. 1825. Descriptions of new Hemipterous Insects collected in the Expedition to the Rocky Mountains. *Philadelphia Academy of Natural Sciences, Journal,* 4 (2): 307–344.

1832. Descriptions of New Species of Heteropterous Hemiptera of North America. New Harmony, Indiana. (See: —*New York State Agricultural Society, Transactions,* 17: 755–812, 1858).

1859. The Complete Writings of Thomas Say on the Entomology of North America. Edited by John L. LeConte. Baillière Brothers, New York.

Scott, John. 1874. On a Collection of Hemiptera Heteroptera from Japan. *Annals and Magazine of Natural History,* 14 (4): 440–441.

Singh-Pruthi, Hem. 1925. The Morphology of the Male Genitalia in Rhynchota. *Entomological Society of London, Transactions,* (1–2): 127–267.

Snodgrass, R. E. 1935. Principles of Insect Morphology. McGraw-Hill, New York.

Somes, M. P. 1916. Some Insects of *Solanum carolinense* L. and

their Economic Relations. *Journal of Economic Entomology,* 9 (1): 39–41.

Stål, Carlos. 1862. Hemiptera Mexicana. *Stettin. Entomologische Zeitung,* 23: 324–325.

1873. Enumeratio Hemipterorum. 11, No. 2, (3): 115–134. Stockholm.

Summers, H. E. 1891. The True Bugs, or Heteroptera, of Tennessee. *Tennessee Agricultural Experiment Station Bulletin,* 4 (3): 90.

Tilden, J. W. 1950. Biological Notes on *Corythucha morrilli* O. and D. *Entomological News,* 61: 135–137.

Twinn, C. R. 1935. A Summary of Insect Conditions in Canada. *Entomological Society of Ontario, 65th Annual Report,* p. 126.

Uhler, P. R. 1878. Notices of Hemiptera Heteroptera in the Collection of the late T. W. Harris, M.D. *Boston Society of Natural History, Proceedings,* 19: 415–416.

1886. Check-list of the Hemiptera Heteroptera of North America. Brooklyn Entomological Society.

1896. Summary of the Hemiptera of Japan presented to the United States National Museum by Professor Mitzukuri. *United States National Museum, Proceedings,* 19: 265.

1904. List of Hemiptera-Heteroptera of Las Vegas Hot Springs, New Mexico. *United States National Museum, Proceedings,* 27: 362.

Van Duzee, E. P. 1889. Hemiptera of Muskoka Lake District. *Canadian Entomologist,* 21 (1): 5.

1917a. Catalogue of the Hemiptera of America North of Mexico. University of California Press, Berkeley.

1917b. Report upon a collection of Hemiptera made by W. M. Gifford. *California Academy of Sciences, Proceedings,* Series 4, 7 (11): 257–261.

Walley, G. S. 1928. Preliminary Study of Male Genital Armature of the North and South American Genera of Tingitidae. (unpublished M.S. thesis in Iowa State College library).

Walsh, B. D. 1864. On Phytophagic Varieties and Phytophagic Species. *Entomological Society of Philadelphia, Proceedings,* 3 (408): 408–409.

Walsh, B. D. and **C. V. Riley.** 1868. Bugs on grapevine mistaken for chinch bugs. Leaf-Bugs, etc. *American Entomologist,* 1: 19.

Weiss, H. B. 1913. Notes on Negative Geotropism of *Corythucha ciliata* (Say). *Journal of Economic Entomology,* 6: 407–409.

1915. Insect Importations into New Jersey during the Spring of 1915. *Canadian Entomologist,* 47 (9): 326–328.

1916a. Foreign Pests Recently Established in New Jersey. *Journal of Economic Entomology,* 9: 212–216.

1916b. Newark Entomological Society (Minutes). *Entomological News,* 27 (4): 189–190.

1918a. The Control of Imported Pests Recently Found in New Jersey. *Journal of Economic Entomology,* 11 (1): 122–125.

1918b. Some New Insect Enemies of Greenhouse and Ornamental plants in New Jersey. *New Jersey Agricultural Experiment Stations, Circular* 100: 1–19.

1919. Notes on *Gargaphia tiliae* Walsh, the Linden Lace Bug. *Biological Society of Washington, Proceedings,* 32: 165–168.

1921. Notes on the Life History and Early Stages of *Corythucha celtidis* O. and D. *Ohio Journal of Science,* 21 (3): 104–106.

1924. *Corythucha marmorata* (Uhler) on Seaside Goldenrod. *Entomological News,* 35: 367.

Weiss, H. B. and **E. L. Dickerson.** 1918a. The Early Stages of *Corythucha pergandei* Heidemann. *Entomological News,* 29: 205–209.

1918b. The Life-History and Early Stages of *Corythucha parshleyi* Gibson. *Canadian Entomologist,* 50 (12): 401–406.

Weiss, H. B. and **R. B. Lott.** 1924a. Notes on *Corythucha marmorata* (Uhler) in New Jersey. *Entomological News,* 35 (2): 68.

1924b. Notes on *Piesma cinerea* (Say) in New Jersey. *Psyche,* 31 (5): 233–235.

Weiss, H. B. and **Erdman West.** 1924. Notes on the False Indigo Lace Bug. *Gelchossa heidemanni* Osborn and Drake, in New Jersey. *Entomological News,* 35: 56–60.

Westwood, J. O. 1840. An Introduction to the Modern Classification of Insects. 2 vols. London.

White, R. P. 1933. The Insects and Diseases of Rhododendron and Azalea. *Journal of Economic Entomology,* 26: 631–632.

Wille, Joh. 1929. Die Rübenblattwanze *Piesma quadrata* Fieber. *Monographien zum Pflanzenschutz,* 2: 1–116. J. Springer, Berlin.

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